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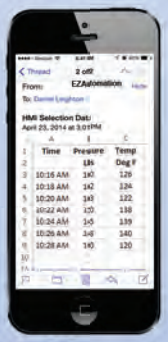

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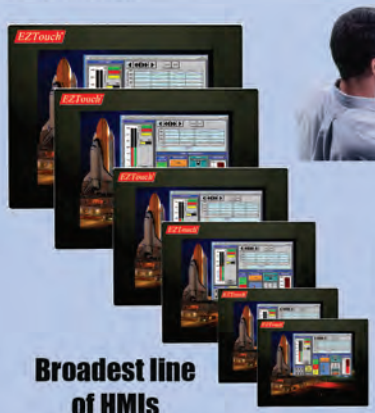

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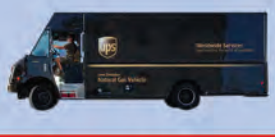

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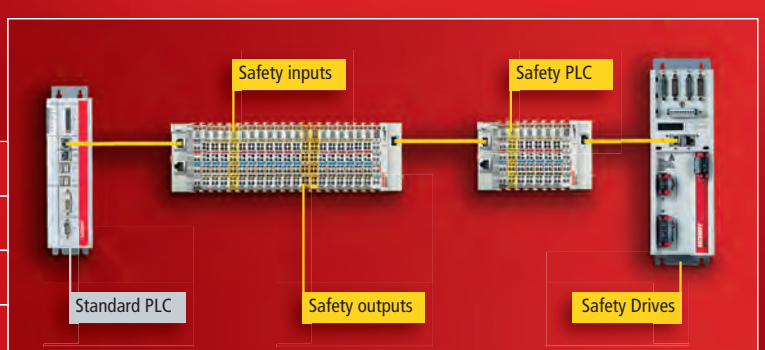

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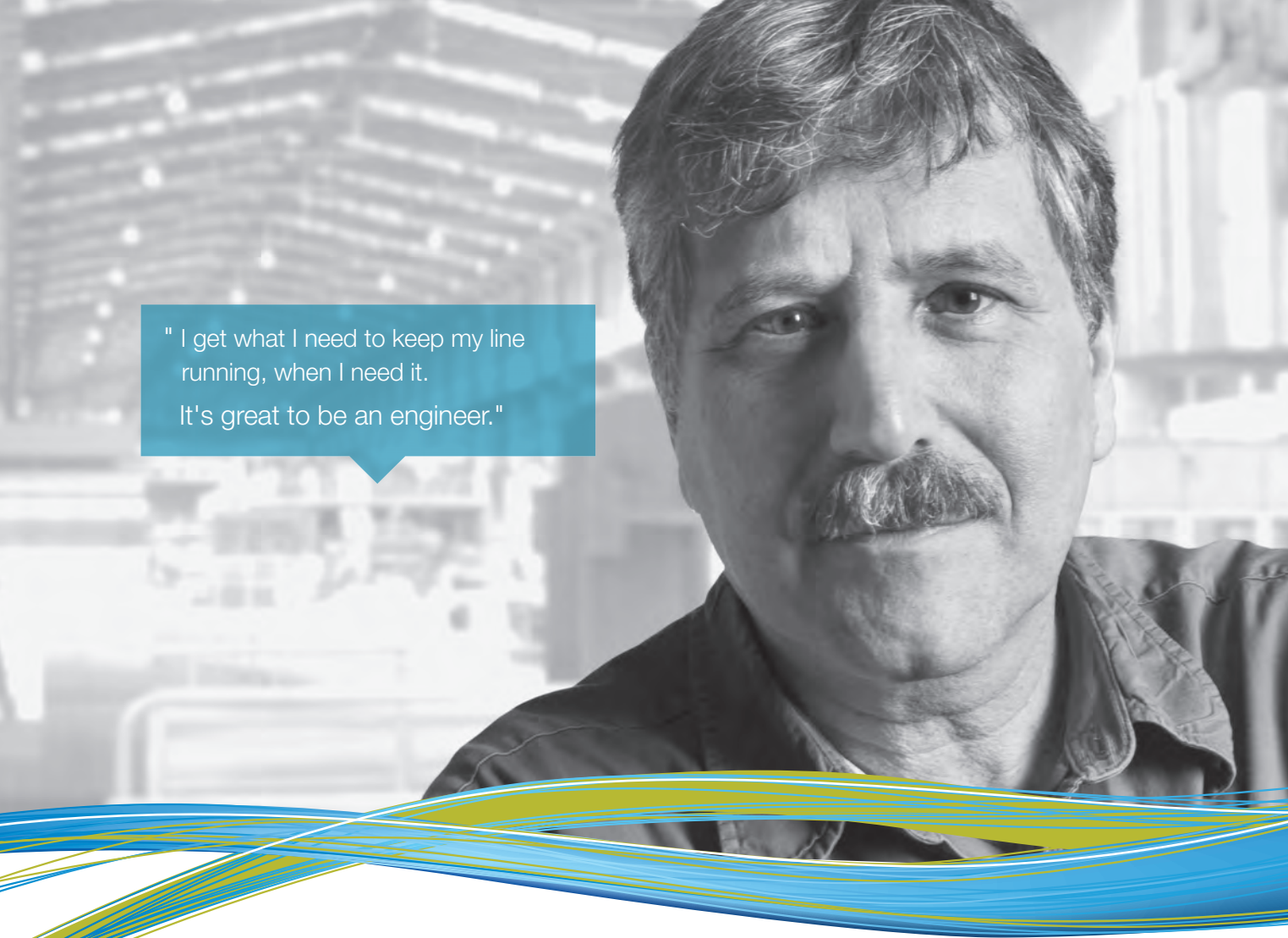

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IoT: Ain't Seen Nothing Yet

AUTHOR JEREMY RIFKIN has written about economic and social trends and issues for years. He says we've entered the third industrial revolution, and we'd better get ready for the changes it will bring.

His new book, *The Zero Marginal Cost Society*, foresees how the Internet of Things (IoT) will lead to nearly free goods and services, diminishing the influence of capitalism and ushering in a global "collaborative commons."

"We're just beginning to glimpse the outlines of the first new economic system since the emergence of capitalism and its antagonist, socialism, in the 19th century. It has long-term implications for us and our children and grandchildren," Rifkin said at a recent speaking engagement at Google's headquarters.

Marginal costs, he reminds us, are the costs of producing an additional unit of a product after fixed costs are covered.

Rifkin talks of a paradox embedded in capitalism that is responsible for its great success, but is now leading to its demise. He says businesses always welcomed the reduction of marginal costs, but "they never anticipated a technological revolution so extreme in its productivity that it might reduce marginal costs to near zero across the value chain, making goods and services essentially priceless, abundant and not subject to a market exchange economy."

He says the first inkling of this paradox was Napster in 1999, which introduced file-sharing and bypassed the recording industry's royalties system. It has since invaded the entire information goods industry. Consumers became "prosumers," producing and sharing their own information goods with videos on YouTube, news blogs and ebooks, and decimated the publishing industry.

"Economists thought there's a firewall here, so these concepts won't cross into the world of brick and mortar goods and services," Rifkin said. "That's not the case."

Rifkin says the IoT Communication Internet is converging with an emergent Energy Internet and Logistics Internet to create a new technology platform that connects everything and everyone. Prosumers will use big data, analytics and algorithms to accelerate efficiency, dramatically increase productivity and lower the marginal cost of producing and sharing a wide range of products and services to near zero.

■ Social capital becomes as important as financial capital; access trumps ownership. ■

This spawns a hybrid economy—part capitalist market and part collaborative commons—with far-reaching implications for society, Rifkin says. Prosumers plug into the IoT to make and share their own information, green energy and 3D-printed products at near-zero marginal cost. They share cars, homes and other items via social media, rentals redistribution clubs and cooperatives at low marginal cost. Now social capital is as important as financial capital, access trumps ownership, sustainability supersedes consumerism, cooperation ousts competition and exchange value in the marketplace is increasingly replaced by "sharable value" on the collaborative commons. cd

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Help Safety Break Free of the Past

TRADITIONAL MACHINE SAFETY is a lot like Ziebart or Rusty Jones. Remember those long-ago rustproofing services? You'd buy a new or at least late-model car, take it to one of their local shops, and they'd drill a bunch of holes in the body and spray in a rust-inhibiting coating. It seemed like a good idea at the time.

Well, I took a new 1987 Toyota Tercel to a local Ziebart, and it got the usual treatment, which I found out included sticking little plastic buttons into and over the new holes inside the door panel, rear hatch and other locations. Even then, this seemed a little goofy to me. I mean, punching holes in a new car didn't seem like a logical way to prevent rust. Why not apply the anti-rust stuff during assembly and avoid all the holes? My concern only grew as the years went by, and I routinely saw rainwater dripping out of the drill holes and little, spidery trails of rust start branching out from under the plastic buttons. Terrific.

I'd bet the whole rust-proofing industry got started because the automakers weren't doing it—given all the rusted hulks we used to see in moister parts of North America. So I'd also guess that Ziebart and other shops and their aftermarket dried up once the car builders started adding some of their own auto-body preservatives before or during assembly.

Similar to the rustproofing saga, machine safety used to be mostly a difficult and often ineffective afterthought. Gates, guards, E-stops, light curtains and other protective devices were added after machines were built, but were so cumbersome that operators frequently bypassed them. In recent years, some standards, such as the National Fire Protection Assn's NFPA-79 rules, have enabled safety and control communications on the same network. This enabled the advent of dual-processor safety PLCs and other components that can be designed into machines and production lines before they're built, and help set up safe zones, safe speeds and safe directions in machines. These capabilities allow operators to interact much more closely with machines with little or no risk of injury or having to completely power down.

The main trick is to plan ahead, include safety functions in initial designs and get protections integrated before equipment is assembled and tested. Many machine builders have adopted these principles and the devices and standards that support them. However, others have been slower to get on board because they've always built and guarded their machines a certain way, or they don't know which standards apply to them, or they're unaware how easy it is to apply new safety PLCs and other components. Changing mindsets is a lot harder than revising designs, and that's why useful foresight is always in short supply.

One thing that could help reluctant builders get over the new safety learning curve a lot faster would be to make today's standards much more available and accessible than they've been in the past. Whenever I cover machine safety, I'm always encouraged by everyone saying how important it is to get builders, system integrators and end users more educated about safety, but then I'm stunned at how few specific details there are about what the primary ISO, IEC, ANSM, NFPA, UL, RIA and other standards require, where they must be applied, and how to comply with them. Most sources say builders must either shell out hundreds or thousand of dollars for their own copies of the safety standards or pay system integrators or certified consultants who are familiar with the standards to advise them.

Standards organizations must be paid for developing safety rules, but they could provide more basic guidance to builders adding safety earlier to their designs.

I know standards organizations must be compensated for the resources they spend on developing safety standards. However, given the paltry details usually available, I also know they could do a lot more to provide basic guidelines and encouragement to builders seeking to add safety earlier in their machine design and prototyping processes.

Of course, this improved outreach by many of the major safety organizations will be even more crucial as the standards themselves evolve and are updated. For example, ISO 13849 just recently took over for EN 954, and builders need to know how to calculate safety performance levels, and not just how to fit into former safety categories. In fact, efforts are already underway to combine ISO 13849 with IEC 62061, and builders need more input on how this will affect them.

Heck, many suppliers and governments might be willing to fund greater dissemination of safety standards to builders because it would mean greater use of safety PLCs and other products, and prevent some tragic injuries at the same time. Just like with rustproofing, safety will eventually get where it needs to go, but why not give it some help along the way? CD

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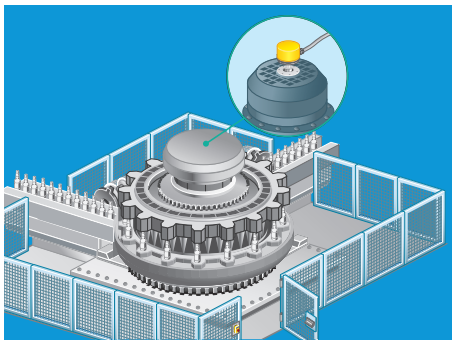

A safety encoder detects when the machine stops, and lets the operator in right away. Unlike traditional setups, encoder-based safety controls can also detect overspeeds and if the machine is turning in the wrong direction.

Factories usually put safety fences around sorters, fillers, and other rotating machines that pose a danger to workers. Gates in fences let operators and maintenance personnel into a machine's workspace only when it's safe. Typically, the worker hits a button that sends a request-to-enter signal to a timer. The timer counts down a preset wait period to give the machine time to come to a halt — even if it was not running at its fastest when the worker requested access. For added security, the machine's drive power is disengaged. Then the gate opens.

A safety encoder detects when the machine stops, and lets the operator in right away. Unlike traditional setups, encoder-based safety controls can also detect overspeeds and if the machine is turning in the wrong direction.

While effective, timer-based safety is inefficient because it results in unnecessarily long wait periods and safety margins to 50%. For example, if a machine coasts to a stop in 30 sec (assuming that a faulty system lacks the means to actively brake), the added safety margin results in a 45-sec wait period — even if the machine was running slowly and can still brake. This increases machine downtime and tempts frustrated operators to bypass the safety devices.

An alternative for rotating machines is to base safety controls on safety-rated encoders. Here, the encoder tracks system speed. When a worker needs to get close and triggers the request-to-enter signal, the controls slow the machine. As soon as the encoder detects that potentially hazardous motion has stopped, the gate opens.

In some cases, encoder-based safety eliminates the need to remove power from the drive: The safety encoders continuously track machine motion and trigger safety shutdowns if a faulty drive tries to start the machine while a person is near.

Safety encoders even prevent machine runaways caused by drive failures that can occur when the drive is programmed with bad limits, the range of movement is incorrectly set, or there are bad references in the motion program. Runaways are dangerous to operators. They also necessitate costly repairs when they cause crashes. Safety encoders can detect overspeeds before a machine goes out of control; then the controls initiate a machine shutdown.

One caveat: Machine-safety systems must incorporate redundancies. Conventional safety devices such as e-stops, for example, have redundant contacts. In contrast, encoder-based safety uses redundancies programmed into a speed-monitoring module. Here, programmed-in logic activates safeguards in response to encoder pulse counts that represent overspeeds and stops. Some setups verify the direction of rotation — useful in applications that can only turn safely one way. Here, if the encoder detects the machine is spinning the wrong way (as the result of a drive failure or PLC programming error), the controller will shut the machine down.

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OCS IntelliTrak's Modular Overhead Conveyors Help Automotive and Subassembly Builders Keep Up With Rapid Design Changes

MASS PRODUCTION USED to mean everyone got the same product. Well, those days are long gone. To accomplish today's goals of producing numerous, customized products faster, automotive and subassembly manufacturers need extreme levels of flexibility in their production lines, and IntelliTrak's overhead conveyor systems give it to them.

Located in Fairfield, Ohio, OCS IntelliTrak (www.intellitrak.com) builds modular, overhead conveyor systems that are used for manufacturing and assembling numerous parts, including front-end modules, door lines, engine lines, instrument panels, seats, headliners and center consoles.

Using technology licensed from OCS in Boras, Sweden, IntelliTrak was founded in 1995, and still produces the only rotating-tube, friction-drive conveyors in North America. Driven by skewed wheels, trolleys ride on IntelliTrak's load rail, while the drive beam's spinning tube is attached via bearing assemblies. Operators can change trolley direction easily by reversing the drive tube's rotation. This rotating tube also requires no lubrication for cleaner, quieter operation.

The flexibility of the company's overhead conveyors, such as its IntelliTrak 500 Series, come from their bolt-together design. This enables easy system changes for new car designs, allows manufacturing zones to be added or removed from the line with minimal impact, eliminates the need for many replacement systems, and reduces downtime and costs.

"Because our customers' needs change so quickly now, 50 to 70% of our systems will be modified within the first five years of implementation," says Tom Robertson, IntelliTrak's president. "Fortunately, we can unbolt the end of our overhead conveyors, and add two, four or eight more stations in just a few hours. This job usually takes two weeks with traditional conveyors. In fact, we recently added a 10-foot inspection station with camera to check airbag switches on the Dodge Dakota instrument panel line at Chrysler's plant in Warren, Michigan, and we were able to get it up and running in just four hours on a Saturday."

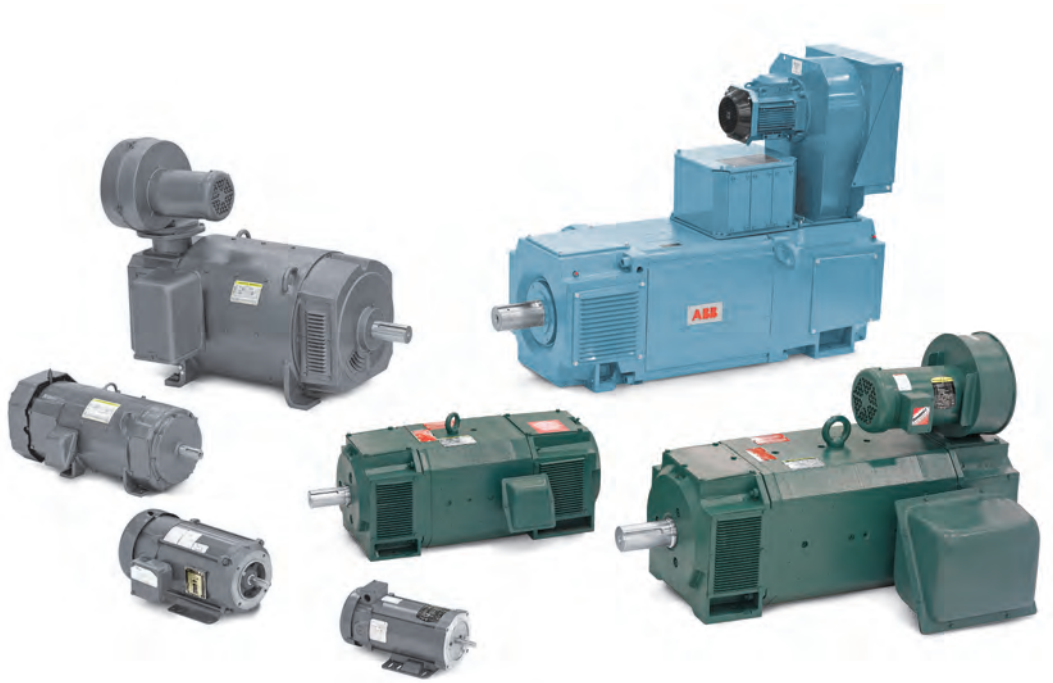
DASHBOARDS DASH

This automotive assembly line uses the Intellitrak 500 overhead conveyor system to build instrument panels, while its modular components can be reconfigured quickly for new designs.

The modularity of IntelliTrak's conveyors is further aided by its controls, which include drives and I/O distributed throughout each separately driven zone. These controls include programmable automation controllers (PACs), distributed motor controllers and I/O modules from Rockwell Automation (www.rockwellautomation.com), which are networked via EtherNet/IP. Distributed motor controls enable each carrier and zone to run independently and at varying speeds, which allows production line speeds to be matched to different assembly tasks, prevents parts from being tied up on the line, increases efficiency and saves time.

"One of our primary benefits is that we can independently control all zones in a user's process and stop, slow, reverse and move carriers back and forth, and even create movement recipes that best suit the geometry needed for each part," explains Robertson. "This means we can clean, paint or assemble many parts much more efficiently. Our distributed drives and remote I/O also mean we don't have to send hundreds of wires back to a main enclosure." CD

DC On Demand



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R.I.P. PLC?

Great to see your March 2014 piece on the PLC ("Live Wire," p. 17, www.controldesign.com/articles/2014/plcs-days-numbered). Quite a statement. This is something I have been saying for some time, although coming from a slightly different context. I got dragged into a silicon start-up specializing in embedded motor control and got exposed to the power and cost of these devices. Five years ago it was possible to make a PLC work on a $6 processor with Ethernet already built into it.

The PLC might be on the verge of extinction as a hardware proposition. The fact that CoDeSys has pretty well co-opted the entire industry is nothing short of amazing. So now that the logic is software-based, there's not much market basis that will sustain hardware. The only thing that will endure is the need for I/O and the ability to host the application for the point of use. How that is implemented can be anything if the application is software-based.

The other thing to factor in is the ladder diagramming language. We've predicted the demise of ladder logic for decades. And it's still here with us. Too much installed base and no obvious replacement.

Manufacturers using the cloud? I don't think this is likely on individual machines. Plant network? Yeah. Corporate IT? Hell, yeah. Why pay for owning all that overhead if someone will host it for you for cheap?

Thanks for taking the risk to say it. I am impressed with your candor. The industry needs more honesty. Let's give it to them.

STEVE MEYER, senior consultant, Solid Tech, www.solidtechinc.com

Are Hybrids the Answer?

(Re: "What Killed the Electric Car?" October 2013, www.controldesign.com/articles/2013/what-killed-the-electric-car)

You overlooked a potential automotive power source—fuel cells, but there is the issue of storing hydrogen and no fueling infrastructure. A parallel hybrid, like the Prius, still requires batteries, though they need not be as large. A series hybrid, like the Volt, is really an electric vehicle that carries an on-board generator and uses a large expensive battery. Neither suffers from the range limitations of a pure electric vehicle (EV). Unlike a parallel hybrid, the Volt can function for a limited range as an EV, whereas a parallel hybrid uses the electric motor to aid in starting from a stop, meaning the hydrocarbon-powered engine need not be as large.

As for non-intermittent, renewable energy sources, I would love to see more use of tidal- or wave- or water-current-based (not dam-based hydro) sources. Interesting reading at www.eia.gov/forecasts/aeo/er/electricity_generation.cfm. Based on that document, new generating capacity will all be natural gas, as that is the most cost-efficient. Offshore wind is the second most expensive, largely due to capital costs, whereas hydro, I guess defined as gravity-driven water, is right in the mix, but location-limited. I have seen designs for water-current-based generators. It would be interesting to see where they fit in the equation.

RANDY ZEITVOGEL, vision specialist, C & N Mfg., www.cnmfginc.com CD

Hannover Fair Introduces "Industrie 4.0"

IN APRIL, more than 180,000 visitors from 100 countries descended on Hannover, Germany, to experience the latest of what's possible in industrial technology. Under the theme of "Integrated Industry: Next Steps," many of Europe's major factory automation suppliers fielded booth demonstrations designed to illustrate their visions of next-generation advanced manufacturing capabilities.

"Industrie 4.0" is an initiative of the German government intended to foster the country's manufacturing competitiveness by leveraging the potential of cyber-physical systems and ubiquitous network connectivity to create more efficient and productive factories, work processes and supply chains.

"Industrie 4.0 will be with us sooner than many people would have thought possible just one short year ago," said Jochen Köckler, member of the managing board for Deutsche Messe, Hannover Fair's organizer. "Exhibitors have demonstrated a clear commitment to negotiating the next steps on the road to the fourth industrial revolution rapidly and purposefully."

Throughout the automation halls, the integration of design and manufacturing platforms was apparent as RFID-badged products moved through modular production lines carrying instructions for their own manufacture along for the ride. Tablet computers and smartphones interfaced directly with automation controllers, or reached up through secure cloud connections to ease engineering and integration tasks, and enable new information transparency.

Secure Communications a Given

Underpinning any effort toward building a more connected industrial supply chain is the need for cybersecurity. Siemens (www.siemens.com) was among the companies announcing new efforts in this arena at Hannover.

Siemens significantly deepened its relationship with McAfee (www.mcafee.com), a division of Intel Security (www.intel.com), to build industry-specific security solutions leveraging next-generation firewalls, security information and event management (SIEM), endpoint security and global threat intelligence. These offerings are intended to provide greater visibility and control at the factory level, while reducing the risk of intellectual property theft.

PUTTING DOWN ROOTS

"Digitized, integrated industry is putting down roots, before growing into a mighty tree," said Dietmar Harting (right), chairman of the Hannover Messe Exhibitor Committee and president of Harting, on the role of Hannover Messe as a showcase for progress toward making "Industrie 4.0" a reality.

"Industrial security is one of the building blocks for strong demand of connected manufacturing environments and for the continued resurgence of manufacturing globally," said Siegfried Russwurm, CEO of Siemens Industry. "This partnership will be an important foundation for the future of manufacturing and Industrie 4.0."

By combining forces, Siemens, Intel and McAfee intend to drive the adoption of connected, managed and secured solutions at the plant level to help industrial customers manage their security, while bringing the uptime and reliability of the plant operations to a higher level as well, Michael Fey, worldwide chief technology officer at McAfee, explained. "We must build new solutions that secure operations, but also enable the user," he said.

NEW AND NOTEWORTHY

ISA (www.isa.org) offers an online, instructor-assisted course that reviews the knowledge and skill areas tested on the Control Systems Engineer (CSE) Professional Engineer (PE) examination. The Control Systems Engineer (CSE) PE Exam Review Course (EN00E–Online) provides the same comprehensive, in-depth review of ISA's classroom-led CSE PE course, but enables students to study at their own pace with 24/7 access to the course materials.

Continued on p. 23

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OXPCIe-952 Isolated RS-232, 2x DB9, isolated RS-422/485

PCM-24D4R2/PCM-24D4R4
OXPCIe-954 UART, Non-Isolated RS-232, 1x DB37, Non-isolated RS-422/485

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Industrial Machinery Market Growth to Double in 2014

HIGH DEMAND FOR machines in manufacturing sectors ranging from automaking to packaging will push the industrial machinery market to new heights during the next five years, highlighted by a doubling of growth this year, according to a new report from researchers at IHS Technology (https://technology.ihs.com).

As economic conditions continue to improve worldwide, the demand for machines in sectors such as agriculture, packaging, materials handling and machine tools will push revenues to $1.6 trillion this year, up from $1.5 trillion in 2013. This represents annual growth of 6.3%, more than twice the 2.9% increase seen in 2013.

Strong growth is forecast to continue for the next four years, with revenue rising to $2.0 trillion by 2018 (see page 22). During this period, the machinery market's annual growth rate will remain quite impressive, averaging between 5% and 6%.

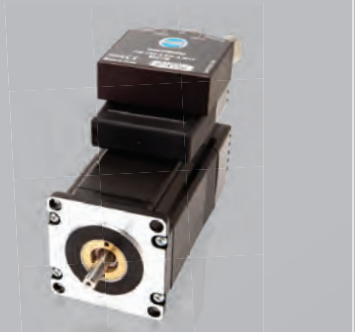
"The improving economic outlook is a key factor in the strong growth of machinery in the coming years," said Andrew Robertson, senior analyst for industrial automation at IHS. "The growing populations and the expanding middle classes in developing countries are generating more disposable income. This translates into increased demand across a vast number of sectors."

Sales growth for industrial machines in 2014 is being driven by a number of factors.

First, higher demand for cars worldwide is spurring the requirement for more spending on tools and robotics in the automotive business, as well as the rubber and plastics segments. Meanwhile, an increase in the standard of living and growing spending on nutrition will benefit the food and packaging machinery sectors.

Furthermore, rising spending on technology products will boost the demand for robotics, semiconductor equipment, mining, and oil and gas machinery.

At the same time, increased demand for housing, infrastructure and commercial buildings is benefiting the construction equipment sectors. Moreover, social awareness of green technologies is resulting in higher demand



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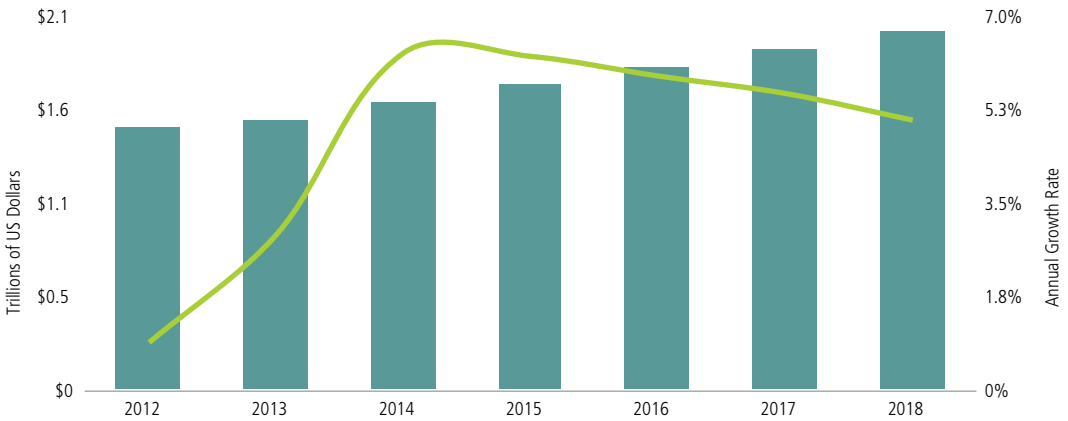
	2011	2012	2013	2014	2015	2016	2017	2018	"CAGR 2011-18"
Revenue ($T)	$1.46	$1.48	$1.52	$1.62	$1.72	$1.82	$1.92	$2.02	4.7%
Annual Percentage Growth		0.9%	2.9%	6.3%	6.3%	5.9%	5.6%	5.1%	



GLOBAL MACHINERY PRODUCTION REVENUE FORECAST AND ANNUAL GROWTH RATES (REVENUE IN TRILLIONS OF US DOLLARS)

High demand across several verticals will boost the industrial machinery market to $2.0 trillion by 2018.

for industrial machines in photovoltaics (PV) and in wind turbines.

These findings are contained in the "Machinery Production Market Tracker," from the Machinery group at IHS.

The growth of the machinery market represents a welcome change from just two years ago when not every region performed well. The Americas prospered in 2012, boosted by a significant government investment that caused machinery production revenue to grow by 6.5%.

In 2013, machinery production growth in the Americas slowed to 2.0%, but still fared better than some of the other regions. In the Asia-Pacific region, however, growth slowed to only 3.5%. A majority of this slowdown came from China, where production remained nearly flat because of overcapacity.

Meanwhile, Europe struggled as a result of the economic problems persisting throughout the region, and machinery production revenue declined by 5.6% in 2012, dragging down the entire global market. Europe increased output last year, but only by 1.1%. CI

NEWS AND NOTEWORTHY

Continued from p. 18

Chemineer (www.chemineer.com) has been chosen by **Cynar PLC** (www.cynarplc.com) as its engineering partner for agitation at the U.K.'s first waste plastic-to-diesel plant at Avonmouth near Bristol. The end-of-life plastics-to-diesel (ELPD) facility is the first of a multi-plant project that will be established across sites in the U,K. Chemineer will supply agitators for other planned sites in the U.K. and Europe.

ABB's robotic division made a gift of $50,000 to the **Oakland University (OU) School of Engineering** (www.oakland.edu/secs), in support of the school's development of a four-year industrial robotics and automation program.

Real-Time Innovations (RTI, www.rti.com), a real-time Internet of Things communications platform company, became an initial member of the **Industrial Internet Consortium** (IIC, www.iiconsortium.org). The goal of the IIC is to accelerate the development of connected industrial applications.

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+ **Integrated system diagnostics** for full transparency of the plant status, automatically generated and consistent appearance
+ **TIA Portal for highest engineering efficiency** to reduce project costs – and naturally with **Safety integrated**
+ Siemens is the global leader in Safety and recognized by Frost & Sullivan for the 2013 Company of the Year Award for Smart Machine Safety Networks and the 2011 Global Machine Safety Customer Value Enhancement Award.

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+ **Seamless integration** with one system, one engineering tool
+ **Standard and fail-safe communication via the same network,** to lower initial and operating costs
+ **Consistent implementation of proven safety technology** to protect lives and increase productivity
+ **Machine safety lifecycle –** savings up to 30% in Total Cost of Ownership

Answers for industry.

Still Feeling Insecure

THE HEARTBLEED SECURITY bug is a programming error in an open-source, encryption-protocol layer of OpenSSL. The gist of the bug is that it allows entry into cached memory that would normally be "malloc'ed" (allocated memory by an application) and protected by that application. So if a hacker can get access to that memory space, which now appears to be unencrypted, then the data that's in that space is easily read.

Believe it or not, the Canada Revenue Agency uses this open-source layer to connect to official users, such as accountants and the general public for e-filing.

I subscribe to an investment service whose site was hacked for reasons unknown. The resulting report from the owner of the site was that the version of WordPress was an older version that had known vulnerabilities, and it hadn't been updated.

By whom? Well, it seems that the creator of the website was using a web-hosting service in California that provided the secure platform and the WordPress application and database as part of its service. So the trust was placed with the service along with the developer.

Misplaced trust can be deadly. The result of the hack was simply to replace hyperlinks and direct users to other websites in Europe and other locales, but the results could have been much more significant.

We do trust in the capabilities of those services that we use—banking, downloads, free apps, etc. Free apps? You have to wonder when a flashlight application for your Blackberry wants to have access to your personal info and turns on your location services. But it is free!

The NSA has brought to light the backdoor theory of almost all systems be they hardware or software. We have relied on the powers that be (read IT department) to keep us safe at work. We rely on our ISPs to keep us safe at home. Maybe we should rely on ourselves a bit more to protect ourselves.

The Apple iOS 7 had a bug that sent out unencrypted data over the network. Anyone that does banking with a portable device is nuts. How can you trust that a flashlight application isn't monitoring and sending info to the mother ship?

Trust with verification is needed, which brings me to the removal of support of Windows XP—a new chapter in the life of automation. If we believe in Murphy's Law, things will hit the fan.

I'm guessing about the total here, but the number of SCADA nodes, HMI boxes and programming laptops still running XP must be monstrous. Everyone wants remote access to everything, and if you use XP as an endpoint, there is now a built-in security risk, since no more patches will be forthcoming. The longer you use XP, the more vulnerable you are. It would almost be best to go back to Windows 2000.

It has been estimated that hardware cycles vary from three to six years. Windows 7 has been with us for five years, XP for 13. Because of the chaos with Vista, not many moved to Windows 7, thus the plethora of computers out there with XP.

The U.S. Navy canceled an order for 1,400 iPads because a portion of the BIOS was written in Russia by Russians. No disrespect to the Russian programming community meant, but there wasn't any love given to them by the Navy.

Cloud-based technologies are safe and cost-effective we are told. Really? Great idea, but maybe not the best implementation.

You have to wonder when a flashlight application for your Blackberry wants to have access to your personal info and turns on your location services. But it is free!

While not all issues are security issues, now more than ever we must be vigilant with our industrial systems. Probably even more so in the future. No one knows what the future holds, but one thing is for sure—the evil doers always will be there and they'll be knocking on our door. We must be as informed and knowledgeable as we can. Being our own advocate is paramount.

In God we trust, yes. But in firmware, software and protocols we can't, or at least we shouldn't.

Off-topic final note: ISA's Automation week in North America, which I pronounced dead two years ago, is officially gone. No longer will the paths of professionals of varying technical disciplines cross in the technical session hall of learning. I'm saddened, but also looking forward to what's next. I just don't know what it looks like yet. Condolences to the ISA and congratulations to the organization for providing so much opportunity for so many over the years. Thank you. CD

JEREMY POLLARD, CET, has been writing about technology and software issues for many years. Pollard has been involved in control system programming and training for more than 25 years.

Safety is Elemental

Once an external add-on after construction, safety is now a fundamental, unifying building block in modern machine design

by Jim Montague, executive editor

Machine safety is moving from the outside to the inside. Traditional guarding and other protections are being replaced or at least supplemented by intelligent, automated safety PLCs, better-coordinated networks and other supporting devices. Integrated into machines at their earliest design and assembly stages, these safety components and software can establish safe zones, guarantee safe speeds and non-injurious motion, and allow operators to stay safe even as they interact more closely with their machines. Likewise, domestic and international machine safety standards are harmonizing to better help builders and users apply common, uniform safety components (Figure 1).

"The Occupational Safety and Health Administration's (www.osha.gov) regulations have been around for more than 40 years, so most companies have some safeguards in place on their machinery, but most of these safeguards are expensive, physical barriers that most likely limit productivity," says Jeff Winter, safety business manager for North America at Grantek Systems Integration (www.grantek.com) in Oak Brook, Ill. "However, recent changes in international safety standards have plowed the road for the rest of the world to integrate safety technology into standard automation functionality. Compared to conventional guarding, we now can reduce hardware costs, simplify control architecture, reduce design and engineering time, increase diagnostics and ultimately make a safer work environment. So even if a machine is conventionally safe, overhauling its safety system could improve its safety and overall equipment effectiveness (OEE)."

For instance, Sandvik Materials Technology (www.smt.sandvik.com) is a worldwide developer and producer of advanced stainless steels, alloys, titanium and high-performance materials, and its cold-rolling mill in Sandviken, Sweden, has been a key part of its precision-strip-steel production line since it was built in the 1930s. The mill is 20 meters long and processes high-carbon steel and stainless grades, and produces strips up to 400-mm wide and 1 to 6 mm thick (Figure 2).

Understandably, the mill's mechanical, electronic and control systems were renovated over the years, and Sandvik recently added servomotors, standard PLCs and touchscreen HMIs from ABB (www.abb.com). However, the company's latest effort to migrate its hard-wired safety systems to zoned safety guarding required it to switch out even more equipment. "We needed to expand the plant and production line's safety, so we decided to install a new control system with a safety central processing unit (CPU) on the cold-rolling mill, but this also meant replacing its safety-related electronics and controls and adding some automatic functions too," says Torbjörn Pettersson, Sandvik's engineering development specialist.

Put Risks into Zones

To find the most appropriate safety and control solution for their cold-rolling mill, Sandvik's engineering and production staffs conducted a risk assessment (RA) in accordance with Swedish directive 2006:4, användning av arbetsutrustning (use of work equipment), and determined the mill needed six different safety zones based on its inlet parts, rolling and removal parts sections.

"It's important to have a risk assessment to start with," Pettersson explains. "After that, you must work through function descriptions and operating instructions. For us, it took a lot of time to find solutions for our new safety functions so they would be safe and productive. Once the instructions are finished, it's much easier to write the safety program. This is important because it can take lot of time to do a new RA and change safety functions and programs during commissioning if the initial solutions don't work out. It's also important to separate safety and the non-safety programs in the controls. This will make it easier to commission and test the safety functions, and these systems will be much easier to maintain because a clear, readable program will minimize the risk of any misunderstandings."

Sandvik also adopted ABB's safety PLC with Profisafe network architecture via Profinet communications protocol to independently control the six safety zones. The new dual-processor safety CPU module and the safety I/O channels are integrated alongside the mill's existing PLC, which controls six dc and ac drives and motors. The dc motors drive the main steel belt and rollers, while the ac motors adjust roller position to achieve desired pressure during strip-steel processing.

This new arrangement with the safety PLC allows parts of the mill to remain operational while an operator gains safe access to some other zone, where

safety is assured by disabling power. About 50 safety PLC I/O channels also link to gate switches, light curtains and E-stop buttons. The I/O points also monitor pressure switches to sense that hydraulic power is disabled for maintenance.

"Establishing safe zones inside machines allows power to be brought to a safe level without shutting down and having to resynchronize the entire machine," says Gary Thrall, senior product support engineer and TÜV-certified functional safety engineer at Bosch Rexroth (www.boschrexroth-us.com). "Similarly, safe-direction functions can be set up in safety zones, so all power won't have to be removed when operators are loading or unloading materials. This can save 10% on many production cycle times."

SAFETY STANDARDS SNAPSHOT

STANDARDS ORGANIZATIONS	STANDARDS DESCRIPTIONS	USA	EU	COMMENTS
International Organization for Standardization (www.iso.org)	ISO 13849-1, functional safety (FS), application-specific (AS), uses performance levels (PLs) ISO 13849-2, FS, validation ISO 12100, FS, risk assessment	X - -	X X X	Can use Safety Integrity Software Tool for the Evaluation of Machine Applications (SISTEMA)
International Electrotechnical Commission (www.iec.ch)	IEC 61508, generic safety standard IEC 62061, FS, AS, uses SIL categories IEC 61511, process safety standard	X X X	X X X	Can use SISTEMA at www.dguv.de/ifa/en/pra/softwa/sistema/index.jsp
U.S. Occupational Safety and Health Administration (www.osha.gov)	OSHA 29 CFR 1910, Subpart O, machinery and machine guarding safety OSHA 29 CFR 1910.147, control of hazardous energy (lockout/tagout)	X X	- -	Safety products and solutions are tested and certified by national, recognized testing labs (NRTLs)
American National Standards Institute (www.ansi.org)	ANSI B11 Series, 2007-2010	X	-	To be followed for application-specific standards
National Fire Protection Association (www.nfpa.org)	NFPA 79, 2012, machine safety NFPA 85, 2011, burner management NFPA 86, 2011, burner management	X X X	- - -	Compliance required; wireless and drives safety allowed
Underwriters Laboratories (www.ul.com)	UL NRGF covers ANSI, UL 508, 1998, NFPA79 and IEC 61508. New UL FS mark is similar to TUV	X	-	New UL functional safety mark and recognition same as TUV certificate
Robotics Industries Association (www.robotics.org)	ANSI, RIA R15.06-2012, ANSI, RIA, ISO 10218-1-2007	X X	- X	Required for all robotic, machine-safety applications
Canadian Standards Association (www.csagroup.org)	CSA Z434, safety requirements for robots and robotic systems	-	-	Required for OEMs shipping machines to Canada

Figure 1: Many local, domestic and international machine safety standards have been harmonizing in recent years, but it's still crucial to investigate which apply to machine builders and their users based on location and particular industrial function and application.

John D'Silva and Siemens Industry

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To conduct thorough, uniform RAs and achieve the greatest practical safety at the design stage, there are a variety of domestic, regional and international machine-safety standards that builders can use. Most significantly, the ISO 13849 standard pushes machine builders and users to move from complying with traditional safety categories to instead calculating and achieving performance levels.

Grantek's Winter adds that, "Risk assessments are like resumes. Everyone has one, but they all look a little different. The important part is they all achieve the same basic purpose and contain the same basic information. For that reason, it's important to use an RA and risk reduction process that works for your organization. The first and most important step is to base your process on nationally recognized, consensus standards, such as ISO 12100, ANSI B11.0 or other industry-specific standards. The second and most challenging step is to develop a procedure and rules to support the process to ensure you have consistent results from one RA to another."

Winter reports that deciding which safety standards to follow begins with the location of the end user's manufacturing facility, and then OEMs, integrators, contractors and everyone else follows suit. "In the U.S., you start with federal and state OSHA regulations, and then use standards it has incorporated through reference, which are primarily American National Standards Institute (www.ansi.org) and National Fire Protection Assn. (www.nfpa.org)." Winter says that because recently revised ANSI standards are starting to harmonize with International Organization for Standardization (www.iso.org) and International

ABB AND SANDVIK

COLD ROLL WITH CARE

Figure 2: Sandvik Material Technology recently added a safety PLC with dual-processor CPU, Profisafe networking and safety I/O channels to its cold-rolling mill in Sandviken, Sweden. This enabled six safety zones and safe speeds in the mill's inlet, rolling and output sections, and improved strip-steel processing efficiency.

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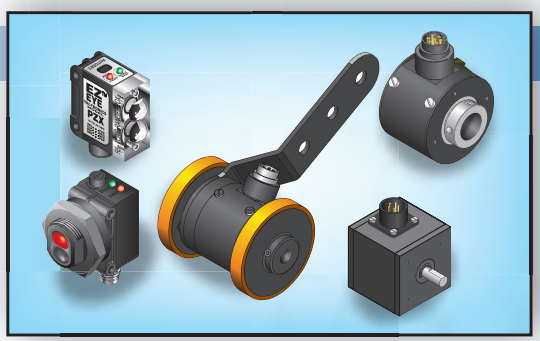

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Electrotechnical Commission (www.iec.ch) standards, it's important to be aware of their contents too. In Europe, this burden is on machine designers and builders.

"Because U.S. and Canadian machine builders and system integrators are at the mercy of clients' requests, they'll follow national or internal standards most of the time," Winter continues. "However, it's not uncommon for them to also embrace unique, company-specific, homemade requirements. Europe has a much more restrictive approach, and to meet the 'presumption of conformity' of the EHS requirements in the Machinery Directive 2006/42/EC, you must follow one or more of the hundreds of harmonized standards listed in the European Union's official journal. In lieu of customer specifications, it's highly advisable to have an internal specification of minimum safety requirements and to list the standards chosen to demonstrate compliance."

To help machine builders learn and perform ISO 13849-1's calculations, the free "Safety Integrity Software Tool for the Evaluation of Machine Applications" (SISTEMA) is offered by the German Social Accident Insurance organization's Institute for Occupational Safety and Health (www.dguv.de/ifa/en/pra/softwa/sistema/index.jsp). The tool provides comprehensive support in evaluating safety in the context of ISO 13849-1.

Safe Motion, New Tools

Besides setting up safe operating zones, the most important benefit of integrating safety PLCs into machine designs is establishing safe direction, speed and other motion that won't allow operators to be injured.

Back at Sandvik's cold-rolling mill, the safety PLC provides safe speed control, which ensures that hands or fingers can't be trapped between the mill's belt and rollers. The safety PLC also allows Sandvik's engineers to use floating-point numbers that simplify safety programming required for tasks on the mill, such as calculating speed. Programming was further simplified by ABB's integrated PLC development tool, which supports safety PLC programming in its CoDeSys-based integrated development environment and supports the PLCopen Safety Library. ABB also provided its own safety code analyzer tool, which verifies safety programming rules.

"Establishing the zones and using the safety PLC improve the cold-rolling mill's safety, but they also aided our efficiency because we designed new functions for threading the strip to separate operator and machine, and this enabled the mill to run more effectively and more safely," Pettersson says.

To help more users gain these safety capabilities, some developers take them beyond the usual safety PLC. For instance, B&R Industrial Automation (www.br-automation.com) just introduced its safety PLC that comes in the form of an I/O module, while its "soft" counterpart is a virtual, purely software-based version that can run on other hardware devices if needed. The PLC provides programmable and network safety to machines that don't need a large complex safety system, according to Corey Morton, B&R's technology solutions director. "Safe motion and safe-limited speeds and positioning can produce big productivity gains because users can maintain existing power, positions and axes in their machines," he adds. "Both approaches can do these jobs."

Similarly, as a longtime practitioner of PC-based control, Beckhoff Automation (www.beckhoffautomation.com) includes its TÜV-approved Functional Safety over EtherCAT (FSOE) capabilities in its existing control systems, which achieve ISO 13849 Level E and SIL 3 ratings. "ISO 13849 went into effect in January 2012, so machine safety's been at the forefront of everyone's thoughts since then, and their awareness is growing quickly," says Tony Rigoni, regional sales manager for northern California and safety expert at Beckhoff Automation (www.beckhoffautomation.com).

Up Into Auto Plants

Of course, once builders and users get a taste of designing and integrating intelligent safety into machines, many want to deploy it in larger production lines and facilities.

For example, Audi (www.audi.com) recently redesigned its A3 model and built a two-level production building at its plant in Ingolstadt, Germany, for its new body assembly line, which operates up to 800 robots in 130 work cells (Figure 3). The A3's lightweight, third-generation body needed a higher-performance production line that was flexible, reconfigurable and able to deliver more sophisticated diagnostics in the cells and on conveyors, so Audi's engineers selected Profisafe and Profinet networking and safety PLCs from Phoenix Contact (www.phoenixcontact.com).

The safety PLC is unusual because it consists of two independent controllers. One is a standard, programmable, IEC 61131-compliant PLC, and the second is a SIL 3-rated safety control system. While one platform is responsible for standard applications and Profinet communications, the other prepares Profisafe telegrams and performs its safety application. This means the PLC executes its standard system and safety programs in parallel, but separate from each other, which ensures independent control and timing for each function and keeps cycle times short for the control and safety programs. Short software cycle times are crucial to maintain optimal production cycle times by the various work steps in Audi's cells. Also, the control of individual command devices such as robots or frequency converters requires a handshake technique,

PHOENIX CONTACT AND AUDI

CAUTION IN CAR ASSEMBLY CELLS

Figure 3: Audi's new A3 body assembly line includes 800 robots in 130 cells which are managed by cell operator control units that have an industrial PC for programming, diagnostics and visualization, and use safety PLCs, network switches and safety I/O modules installed in a lower unit for easy access.

which means added PLC cycles are needed. However, Audi's engineers report that this solution helped reduce PLC cycle times to an average of 12 milliseconds, which means the cycle time of the larger cells could be reduced by up to one second.

Also, once the PLC's programs are validated, they're password-protected to prevent unauthorized changes, while access to the PLC's safety components also can be password-protected for added safety during start-ups.

Similarly, Kia Motors (KMC, www.kia.com) builds three SUV models, which make up more than half of the almost 230,000 vehicles it produces each year, at its Kia Motor Slovakia (KMS) division in Teplička nad Váhom. The body shop at KMS and its body-complete (BC) line assemble all moving parts with manual handling performed by 20 workers and equipment managed by controllers and software from Rockwell Automation (www.rockwellautomation.com).

"It's important to have a risk assessment to start with. After that, you must take lot of time to work through function descriptions and operations instructions. For us, it took a lot of time to find solutions for our new safety functions so they would be safe and productive."

The controls are programmed with two interconnected tools. An engineering tool configures the Profinet system hardware and creates the standard IEC 61131 application, and the safety PLC's software handles the safety PLC. Safety functions of each cell, including emergency stops, protective door contacts, guards in loading and infeed areas, and safety-related robot and drive functions, are programmed in the safety controller.

Unfortunately, the BC line also suffered frequent breakdowns that decreased productivity and sometimes caused the entire line to stop.

KMS reports its BC line had been using Sick's (www.sick.com) safety relays and safety scanners, which it says had complicated wiring and long conductor routing from safety devices to relays in the main cabinet and lacked a bypass function from the scanners. Though traditional relays long have prevented hazardous interactions between operators and machines, KMS adds its safety relays also caused many small line stops, and often made it hard to identify why and where they were happening.

Consequently, KMS decided to add Allen-Bradley safety PLCs to its ControlLogix control system. The BC line added remote safety I/O modules and connected to the plant's EtherNet/IP network, which allowed visualization of safety conditions, alarms, emergency events and programming developed for its HMIs. Previously, if a person entered a cell, or if a device failed during production, the entire line stopped, and each area had to be checked to find the source of the fault. Now, the BC line is divided into five zones, each with a cabinet with Safety Point I/O components and only two or three meters of wiring. Each safety I/O is connected to the safety PLC via EtherNet/IP. So when the BC line is interrupted, only the relevant zone is stopped, which indicates its location and enables quick recovery while other zones remain operational.

"With the ability to identify failures and solve problems quickly, we've increased productivity by reducing safety breakdown time up to 70%," explains Ondrey Vasek, body shop maintenance manager at KMS. "The body-complete line is easier to maintain and makes our lives easier." cd

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The Not-So-Odd Couple

Like an Old, Married Couple, a Motor and Its Generator Are Bound Together. One Does Not Exist Without the Other

by Ernst Dummermuth

FLASHBACK **We celebrated our 15th anniversary two years ago by republishing some of our more timeless content. It was really well-received, so we decided to do it again from time to time. Here's a tutorial article as we we first published it in March 2008. This is one of several that Ernst Dummermuth wrote for us that generated a large number of views on ControlDesign.com for years after we first posted it, and it still draws attention today.**

SOME IMPORTANT PROPERTIES and characteristics of electric motors and electric generators can be demonstrated easily using an actual motor and generator. Grade or middle-school students could conduct these experiments. Through my own experience, I've observed that these experiments, executed on a laboratory table, can be very useful as a teaching tool.

Basically Speaking

Motors come in all shapes and sizes and are used mostly to convert electrical energy to mechanical energy via the rotation of a shaft. The primary electric source in a home is single-phase, 110 Vac. For simplicity and reduced control circuits, many of these motors turn only in one direction. In your car, the motors run on 12 Vdc—the starter being the strongest electric motor in a conventional automobile.

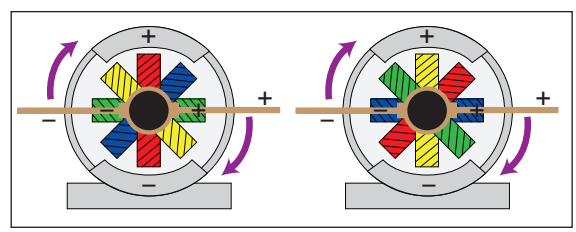
Industrial applications often require much higher mechanical outputs and use much larger motors designed for higher dc voltages or multi-phase ac voltages. These motors also have much higher current ratings.

Generators usually aren't found in a household. Some houses have emergency generators in case power is lost. Every automobile has a generator to provide electricity for ignition, various fans, accessories and lights, and to recharge the battery.

On the whole, most generators are big and supply power grids with electricity. It takes a lot of mechanical power to crank these shafts. Mechanical power is obtained by making steam in power plants from coal, gas and nuclear sources, with diesel engines or hydro turbines, or more recently, with wind turbines on hilltops, often in groups as windmill farms.

Motor Designs 101

Motors are based on the principle that opposite polarity magnets attract each other, while magnets of the same polarity repel each other. One magnet is located on the stator, and one magnet is on the rotor. If those magnets aren't lined up, the rotor will turn until they do. Once the magnets are lined up, rotation stops.



DC MOTOR DYNAMICS

Figure 1: The stator has the fixed permanent magnet, while the rotor is composed of a number of windings. To sustain rotation, and since the permanent magnet can't be reoriented, the electromagnets must be activated or deactivated. This shows rotor position at start-up and after one commutation.

These magnets could be permanent, rare-earth magnets or quasi-permanent magnets—electromagnets with coil windings driven by a dc current. The other magnet is an electromagnet, the orientation of which is modified continuously. As a result, the rotor keeps trying to line itself up. If this magnet modification is done in an intelligent way, such as in a rotation to the right, then the rotor will rotate to the right.

DC Motors

To sustain rotation, and since the permanent magnet

BASICALLY SPEAKING

MBF

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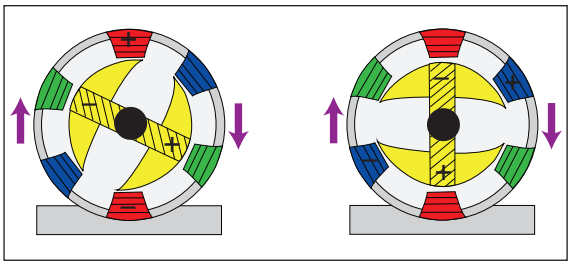
can't be reoriented, the electromagnets must be activated or deactivated. In a typical dc motor (Figure 1), the stator has the fixed permanent magnet and the rotor is composed of a number of windings.

Basically, one or two windings are activated at a time via commutation, depending on the number of coils on the rotor. At start-up (referring back to Figure 1), the green winding is activated. With the polarity shown, the rotor will turn clockwise, trying to align the green magnet with the stator magnet. As the rotor turns, the blue coil becomes activated, while the green coil is deactivated, and so on, as shown



THE BRUSHLESS DC MOTOR

Figure 2: The permanent magnet is on the rotor. External solid-state switches turn on the proper stator winding as a function of the rotor orientation.

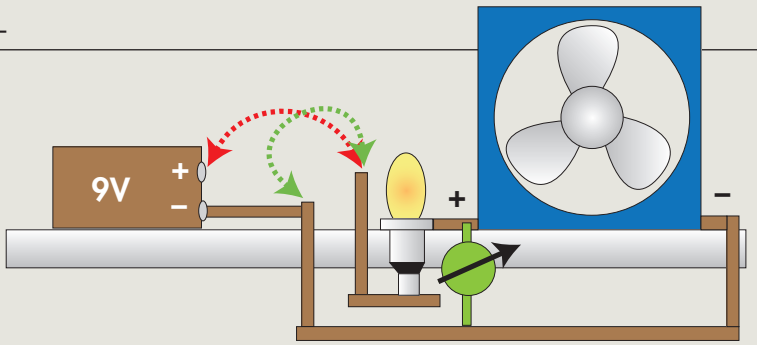
THE MOTOR EXPERIMENT

For this demo, I used a Comair-Rotron Model MD12B1 brushless dc motor. Get a 9-V alkaline battery with a snap-on connector, an alligator clip, a PR3 flashlight bulb and some copper wire. You'll also need a small soldering iron and solder to make connections.

Mount the fan, battery and flashlight bulb on a piece of plywood. Drill a hole to stick the lightbulb into the plywood, and drill smaller holes as needed to run wires from top to bottom for conductors or for fastening equipment.

Motor behavior can be observed under all conditions—stalled, start-up, some load, no load—by controlling the movement of the fan with your hand. These same characteristics are present in high-powered motors.

Notice the relationship between the current through the motor—indicated by the brightness of the bulb—the voltage on the motor and its speed for various operating conditions. Voltage can be measured with a voltmeter.

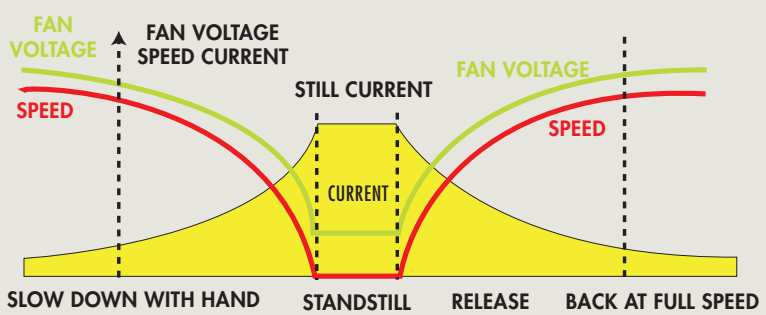


A high stall current, or start-up current, is typical for motors. At start-up, the bulb shines brightly and then dims while the current decreases until full speed is reached, and just a weak glow remains. The voltage across the fan increases with speed. This voltage is the back-electromotive force. Because the fan is turning, it becomes its own little generator, generating a voltage that opposes the 9-V battery, and in the experiment at full speed, it was measured at about 7.0 V, with the battery itself holding at 7.7 V.

Indeed, every motor generates this back-EMF while rotating. The back-EMF opposes the current flow into the motor. It's actually a smaller current back out of the motor in the opposite direction. So every motor is a built-in generator. If this fan is forcefully made to rotate even faster, then the opposing back-EMF voltage may eventually exceed the battery level, and the battery will begin to recharge.

A strong hair dryer can help to verify this behavior. If air is blown into our experiment fan to help it rotate faster, the light bulb completely darkens, and the back-EMF is increased. If air is blown from the other side to slow down the fan, the lightbulb gets brighter, since the back-EMF is now reduced because of increased load.

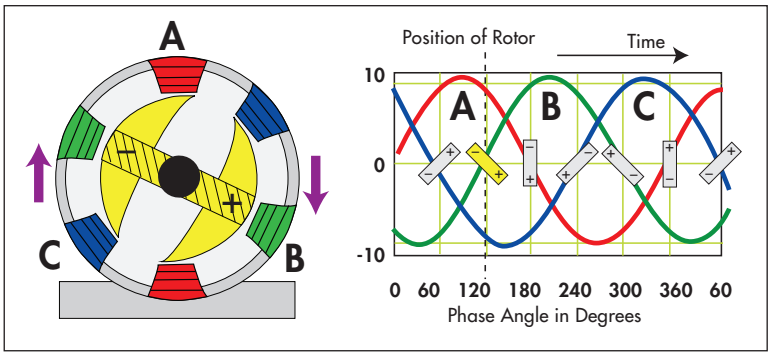
The generator capability can be demonstrated with the battery removed from the circuit. Using the hair dryer, blow air into the fan, making it spin backward. Once the fan turns fast enough, the lightbulb will glow since the fan is generating power. Generally, blowing from either side will work, but this particular fan motor is polarity-protected, so only one direction works.



after first commutation. The rotor field is reoriented in discrete steps, according to the number of rotor windings, while the rotor turns. Details about pole shaping and arrangement of air gaps aren't shown. The rotor could have many more individual windings, and for that reason, two or three adjacent windings could make contact through commutation at any one time.

In another form, called a brushless dc motor or an inside-out dc motor (Figure 2), the permanent magnet is on the rotor. This magnet again can be a rare-earth magnet or a fixed electromagnet connected via slip rings. External solid-state switches turn on the proper stator winding as a function of the rotor orientation. The commutation takes place in the stator windings.

When the red stator coil in Figure 2 is turned on, the rotor moves clockwise, trying to align the opposite poles. At that time, commutation moves to the blue coil and then to the green coil and so on. At nominal speeds, the excitation moves from one phase to the other, turning the different stator coils on and off. At standstill and low speeds, the active stator phase isn't a pure dc signal, but is a pulsed dc signal to avoid saturation. For higher power systems, an almost perfect three-phase excitation is created through solid-state switches.



SYNCHRONOUS = AC BRUSHLESS

Figure 3: In general, the outside field for a synchronous motor is a three-phase sinusoidal excitation obtained from the three-phase, 60-Hz line.

Synchronous Motors

A synchronous motor is basically the ac equivalent of the brushless dc motor just discussed. In these motors, the rotor turns at the same speed as the outside field. In general, the outside field for a synchronous motor

is a three-phase, sinusoidal excitation obtained from the three-phase, 60-Hz line. When no mechanical load is connected to the motor, the rotor is lined up almost exactly with the stator field (Figure 3). As the mechanical load increases, the rotor lags the stator field by several degrees, but is still in step with the field. If the load is increased beyond the rated value, the rotor will fall out of synch and stop.

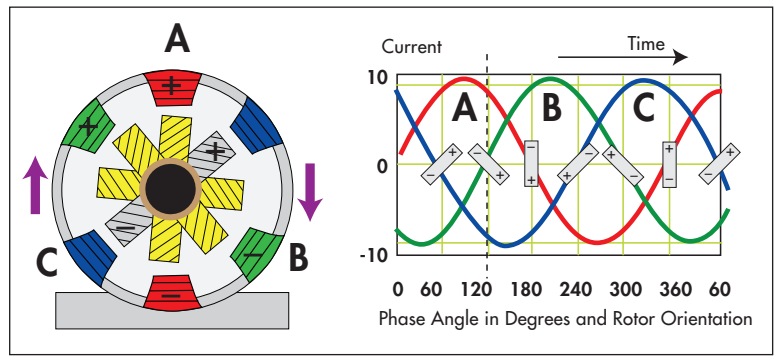
With a moderate load applied, the rotor follows behind the stator field by several degrees. If the load increases, the lag increases and vice versa.

A synchronous motor can't be started from standstill by simply turning on the three-phase ac. It needs to be brought up to speed by auxiliary means before it can be connected to the line. Then it turns synchronously with the three phases no matter what the torque.

Induction Motor

At first glance, an induction motor (Figure 4) looks like a combination of the dc motor (Figure 1) and the synchronous motor (Figure 3). It has many rotor windings, similar to the dc motor, but they aren't connected to any external source or commutation. These are individual short-circuit windings in different orientations.

If a fluctuating stator field is applied, the changing magnetic flux induces a current in at least one of the rotor windings and, thus, creates a rotor magnet of opposite polarity in that plane. At the same time, the current in the other stator windings—60° and 120° offset to the rotor magnet—produces strong stator magnets. As with the dc motor, the rotor now rotates to align. After a 60° turn of the rotor, the stator excitations also have changed by 60°. The new stator field now excites the rotor winding again, and the strong stator magnets now appear 60° turned. Note that the rotor magnet is reestablished through induction when the current in the stator changes most rapidly at zero crossings of the stator current.



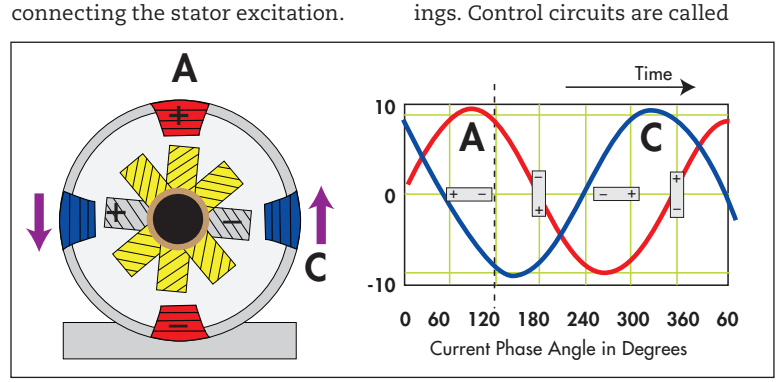
INDUCTION MOTOR CHARACTERISTICS

Figure 4: While an induction motor also has many rotor windings, they are individual short-circuit windings in different orientations.

The condition described here is under no load. Under load, induction motors turn more slowly than the driving stator field. This speed loss is called the slip. When slip occurs, the rotor basically falls one rotor-winding back and continues to fall further back over time. Slip increases with load. If the load is excessive, the rotor will drop out and come to a halt. Because of that slip, however, induction motors can start from standstill by just connecting the stator excitation.

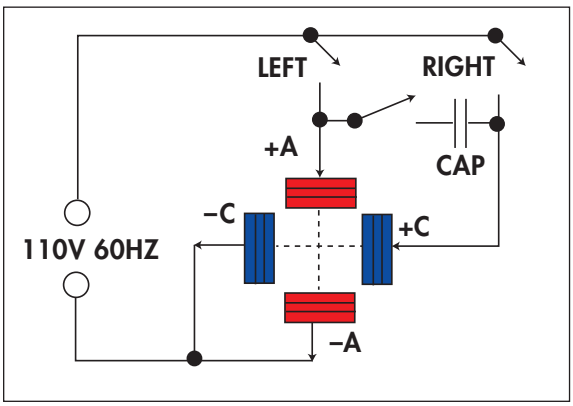
In the gray rotor coil in the illustration, the current in *C* changes rapidly, going through zero. The rotor magnet is established in the gray coil through induction. At that time, *A* is positive, *Not A* is negative, *B* is negative, and *Not B* is positive. We can see that the rotor will move clockwise and follow the rotor movement and the corresponding stator fields along the time line.

Many applications use three-phase 60-Hz line directly, but advances in solid-state power switches made it possible to create three-phase, quasi-sinusoidal phases at virtually any frequency. The incoming ac is rectified, and a dc voltage is created. The dc is switched in a sophisticated sequence in the three-phase windings. Control circuits are called



SINGLE-PHASE START-UP

Figure 5: With a single-phase source, low-power induction motors temporarily require an auxiliary phase via capacitor connected to the primary phase.



SINGLE-PHASE START-UP HELP

Figure 6: Circuit for single-phase induction motor with required auxiliary phase to initiate motor start-up.

variable-frequency inverters or solid-state drives because the primary applications are servo drives.

Since the rotor slips, very accurate position and velocity feedback are needed to properly control the artificial phase generation. Control is difficult at low speeds; at standstill, it becomes tricky. Actually two rotating excitations with equal strength are overlapping each other; one rotates left, and one rotates right. When a command is given to move right, the strength of the left excitation is diminished, and the strength of the right one increased. Eventually, the left one disappears completely once the motor is on its way.

Low-power induction motors can be driven from a single-phase source (Figure 5). However, the single phase isn't sufficient to get the motor started from a standstill. An auxiliary phase is required. A capacitor is connected to the primary phase to create the auxiliary phase 90° ahead of the primary. This creates a rotating field. Once the rotor reaches its rated speed, the auxiliary phase can be disconnected.

Observing the gray rotor coil, the current in *C* changes rapidly, going through zero. The rotor magnet is established in the gray coil through induction. At that time, *A* is positive and *Not A* is negative, and the rotor will move counterclockwise. After 90°, *C* is negative and *Not C* is positive. At the same time, the current in *A* changes rapidly and reestablishes the rotor magnet. A circuit diagram (Figure 6) shows the connections for a single-phase induction motor.

Generators

The dc motors in Figures 1 and 2 already have been presented as dc generators. Indeed, some current ripple exists as commutation takes place. This is true for both motor and generator.

The synchronous motor in Figure 3 needs no modification to run as a generator. In motor mode, current flows from the source into the stator windings, and the rotor lags behind. If the rotor is driven by an external force, such as a turbine, to overtake the outside rotating field, then current flows from the windings back to the source, and the rotor now leads the rotating field. This is the primary mode of electric power generation.

Because it has no magnetic field of its own, and because it slips with varying loads, the induction motor in Figure 4 isn't typically used as a generator. It still has the same properties, however, and certainly develops a back-electromotive force. Running in idle, this back-EMF is nearly as large as the driving voltage. Under load, turning more slowly, the back-EMF is reduced, and the motor consumes more current. In a stalled condition, like the dc motor, it draws very large current. CD

In 2008, Dr. Ernst Dummermuth was a consultant in process control, motion control, automation and intellectual property. He has been involved in advanced technology endeavors including architecture proposals, fast prototyping, concept verification, standardization and product development. His work has yielded 46 patents and dozens of publications. You can reach him at ehdummermuth@juno.com.

MORE, MORE, MORE

Dr. Dummermuth has contributed several well-received technical articles to CONTROL DESIGN during the past few years.

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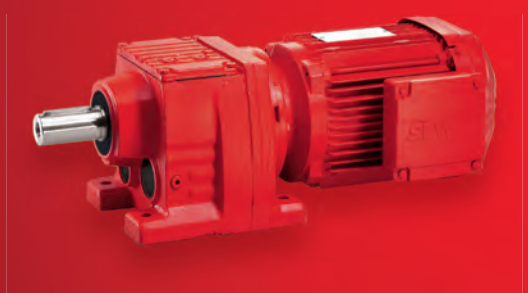

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Get in Touch With HMIs and Machines

MACHINE-TO-MACHINE communication might benefit from the right touch—specifically the right multitouch input displays. Along with the ability of modern HMIs to remotely collect data, the technology could give control engineers new tools and capabilities.

An example of how this might unfold comes from Lenze (www.lenze.com). The automation supplier announced a panel controller a year ago that features an ARM processor, Ethernet connectivity, a USB port and a resistive touch display.

Importantly, its operating system is Windows, and that brings a host of features, explains Lenze's technology evangelist Tom Jensen. These include the ability to easily pass information around and the power to graphically display it, leading to some interesting usage scenarios.

"If I have one HMI and two machines, when one machine burps, the HMI will notice and automatically ask, 'Hey, do you want videos to help troubleshoot this other machine? Yes or no?'" Jensen explains.

The two machines operating under such unified control could be an application, such as a filler-capper combination, which are used in pharmaceutical or beverage processing. These devices might process 250 units per minute for pharmaceutical operations and as many as 1,200 per minute in the case of beverages, according to Jensen.

In part, this new approach that could involve troubleshooting videos is now possible because the devices have the computing horsepower to oversee several multi-axis motion operations simultaneously. They also can handle the data load associated with a high volume of manufacturing throughput. Software running on the devices also can react to defined conditions, such as an alarm, a changeover request or a need for maintenance. In those cases, a video could pop up and guide personnel through the appropriate actions to take.

Some of Beckhoff Automation's (www.beckhoff.com) industrial display families have multi-point projective capacitive input. This means that swiping, flicking, zooming and other operations found on consumer devices are possible. That familiarity brings benefits.

"It's much easier for training in an international market to get operators to understand a machine and navigate the different HMI screens more efficiently," says Nathan Eisel, Beckhoff's North America support manager. He adds that the input technology can be used with thin gloves on, unlike some other multitouch technologies.

Behind the scenes, the use of OPC UA means that the devices can exchange data with other machines. Beckhoff's products can be either the client or the server without hardware add-ons. Thus, they can do machine-to-machine communication with other systems on the plant floor. Beyond that, they can also talk to management systems and move data from shop floor to top floor and vice versa, according to Eisel.

Looking forward, he sees two trends. One is unification of HMI and controllers into a single unit that talks both upstream and downstream, interacting with machines and management systems. The other is a change in the input and display systems. For example, Beckhoff Automation has studied the use of Google Glass, which integrates a heads-up display with a camera, in an industrial environment. The technology could indicate things to come—the birth of a wearable HMI.

Machine-to-machine communication and a modern, touch-enabled device means there's no need to stand around an HMI to diagnose and solve a problem.

HMIs today are the main point of decision-making for operators, and this will continue in the future, notes John Dirks, global product manager for Rockwell Automation's (www.rockwellautomation.com) PanelView Plus. The product family has panel sizes as small as four inches, with a 19-in. display planned.

In Spring 2013, the company announced a new version of HMI software. It allows its panels to connect to and display data from noncontrollers such as power monitors or smart overload relays.

As time goes by, the computers behind the panels will produce a wider array of data and will interface with more systems on and off the plant floor. Some of this data will be accessed remotely. For instance, the manager of a beverage plant might need to access a screen showing a key performance indicator of a bottle-filling machine. That can be done by connecting to the filling room HMI and extracting the data. This sort of machine-to-machine communication and a modern, touch-enabled device mean there's no need for personnel to stand at an HMI to diagnose and solve a problem.

As Dirks says, "The support person, be they maintenance, operations or an engineer, can connect into the terminal, see exactly what's going on and be able to walk an operator through some troubleshooting steps without having to come out on the floor." CD

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"Programmable controls increasingly are moving on-machine," adds Geoff Sieron, GuardLogix safety controller product manager, Rockwell Automation. "The on-machine approach simplifies design and cabling, and reduces maintenance costs. With M12 quick-disconnect cables, it's much easier to install or replace I/O connections without additional wiring."

"One of the problems that programmable controls address is the lack of skilled labor in proportion to the worldwide demand for consumer goods production," argues David Bachman, product manager, c3controls. Economies are bouncing back, and an expanding middle-class is creating a demand for more products. But there aren't enough workers for that demand. To meet consumer demand, goods manufacturers can either work faster or automate. Our controllers self-check and determine not only when they need attention, but also when something in the application itself needs attention."

Tom Schermerhorn, CEO of CTC, says, "We made the strategic decision to support EtherCAT based on feedback from customers who are under greater and greater pressure to develop machines and systems with two specific characteristics: First, the builder or integrator has the design flexibility to choose the best components for the project, and be confident the component devices will play well together. Second, the builder can develop, prototype, set up, test and move the machine/system to the user's site with minimal interruption to the manufacturing process. Since EtherCAT obviates the need for much point-to-point wiring and is supported by many devices in our industry, it was a natural choice to move in that direction."

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Siemens Industry; 800/333-7421; www.usa.siemens.com/plc

CONTROL THE HEAT

UTAdvanced hybrid temperature controller combines PID control with embedded ladder sequence control. It supports 84 ladder commands, 24 DIO points, four analog inputs and three analog outputs. Up to 500 ladder steps can be programmed and run with the PID control. It has full text scrolling configuration prompts, three configuration levels, user-defined function keys, user-settable default values and multiple language support, along with a NEMA 4/IP56 front panel, USB powered configuration tool with software and fuzzy logic.

Yokogawa; 281/340-3800; www.utadvanced.com

YOU LOAD 16 AXES

Compact rack-style Model 5300 PAC with up to 512 I/O and 16 axes of advanced motion control and data logging can be used stand-alone or networked via its serial and LAN connections. Built-in web server provides Internet or intranet access fast. Programming is handled in QuickBuilder state language, or advanced applications can use C/C++.

Control Technology; 888/818-2600; www.ctc-control.com

EMBEDDED CONTROL

Multi-core Intel Atom E3800 embedded computers operate from -40 to 85 °C. They include on-board USB, gigabit Ethernet, serial ports and additional I/O expansion through MiniPCIe and IO60 connectors. They maintain a low thermal design power (TDP) range of 5 to 10 W. Intel Generation 7-based graphics engine supports up to two simultaneously active displays with interfaces available for analog VGA, DisplayPort 1.1 and LVDS connections.

WinSystems; 817/274-7553; www.winsystems.com

OPEN TO LOGIC

MLC motion logic controller version 13 supports integrated safety, robotics and new application development. Integrated CIP Safety on Sercos protocol ensures safe communication from the controller to the drive without additional wiring. Open Core Engineering functionality enables creation of machine applications using any platform and programming language. FlexProfile on the MLC creates motion profiles without costly programming.

Bosch Rexroth; 630/654-0170; www.boschrexroth-us.com

PLC+HMI

FT1A SmartAxis Touch with 3.8-in. touchscreen interface and logic controller in one has a built-in RJ45 Ethernet port and an embedded RS232C/RS422/RS485 interface terminal. Available in 65K TFT color or STN monochrome display with brightness to 700 cd/m^2, the unit has 12 I/O (eight inputs, four outputs), 10-A relay outputs, built-in, two-point, analog inputs and 5 MB of programming memory. Automation Organizer software suite includes WindO/I-NV3 software, and the controllers support ladder, function block and script programming.

IDEC; 800/262-4332; www.idec.com/touch

PROTOCOL FLUENCY

PFC200 line of four controllers combines dual Ethernet ports with multiple fieldbus interfaces, enabling the controllers to serve as fieldbus gateways while communicating with other control systems. Users change between integrated ports to switch a field device between CANopen, Profibus or

Serial RS-232/RS-485 within one unit with no third-party converters. The devices have a 600-MHz ARM Cortex-A8 processor, and compatibility with DHCP, DNS, SNTP, FTP, TELENET and HTTP protocols enables the units to interface with standard PLC applications and additional control systems.
Wago; 800/din-rail; www.wago.us

ON-MACHINE CONTROL

Armor GuardLogix programmable automation controller (PAC) can be installed directly on-machine with pre-configured, quick connect systems to simplify wiring layouts. The PAC is IP67-, SIL 3-, PL(e)-, CAT 4-rated with 4 MB of application code storage space with two full-featured EtherNet/IP device-level ring (DLR)-capable connections. It provides access to the controller-mode switch, USB port, secure digital (SD) card and power-supply switch, along with 24-Vdc power pass-through to supply power to other on-machine products. The controller is programmed in the Studio5000 design and engineering environment.
Rockwell Automation; 414/328-2000; www.ab.rockwellautomation.com

TEMPERATURE CONTROL

Nanoline controllers include a temperature expansion module and an operator display for connection of two RTDs or thermocouples, and is compatible with PT-100 and PT-1000 in two- or three-wire configurations or thermocouple Types B, E, J, K, N, R, S and T. It has four PNP outputs rated at 500 mA each and two temperature inputs. Color-switchable dot-matrix display offers up to four lines with 20 characters per line. It's programmed with free nanoNavigator software with relay ladder logic (RLL) or flow-chart language.
Phoenix Contact; 800/322-3225; www.phoenixcontact.com

UNIFY THE LAYERS

PACSystems RX3i modules provide communication protocols as in-rack solutions standardized on Profinet, and include IEC61850, DNP3 and IEC60870-5-104 Ethernet-based communication protocols. The modules enable two-way communication between the SCADA and intelligent electrical device (IED) levels. By uniting the control and software layers under a common architecture, information stored in the controller becomes more accessible and actionable.
GE Intelligent Platforms; 800/433-2682; www.ge-ip.com

FAST PICKUP AND DELIVERY

Sysmac NJ machine automation controller provides direct control of up to eight Delta robots in multiple conveyor pick-and-place applications with a single controller. The controller CPUs have the same functionality as standard NJ5 CPUs with addition of dedicated robotic function blocks (FB) in Sysmac Studio software. Update time is 1 ms with up to four robots and 2 ms with five to eight robots, and can be synchronized with multiple conveyors.
Omron Automation and Safety; 866/88-omron; www.omron247.com

ROLL YOUR OWN PLC

OEMs can custom-build an in-house PLC for their own line of equipment products. Design one's own carrier I/O board and snap on the SmartTile integrated logic engine. Programmed in iTriLogi Ladder+Basic language, it includes an integrated Ethernet port and carries all the processing capabilities of company's F-series PLCs, including floating-point math.
Triangle Research Int'l; 877/874-7527; www.triplc.com

SIMPLER SAFETY

SC26-2 programmable safety controller uses safety function blocks, Boolean logic functions and a user-friendly programming environment to create safety control logic. It has 26 input terminals and two redundant, solid-state safety outputs to monitor E-stop buttons, rope pulls, interlock switches, safety light curtains and other input devices. Free configuration software has pre-configured safety function blocks, a ladder logic diagram, and text-based summary of the input device and controller output settings.
Banner Engineering; 888/373-6767; www.bannerengineering.com

STUDIO SUPPORT

Apax-5620 with Intel XScale PXA270 CPU supports Microsoft Visual Studio .Net for PC-based users to develop applications. Two CAN bus interfaces support CANopen stack, and two RS-485 ports connect to remote I/O devices, and support up to 32 I/O modules. It's compatible with IEC-61131-3 based Multiprog KW languages and supports WinCE.

Advantech Industrial Automation; 800/205-7940; www.advantech.com/ea

MULTI-TASK CONTROL

MultiCell Type 8619 multichannel controller can be used for regulation of pH, dosing of chemicals and ratio control. The controller is factory set to customer specifications. Standard version includes user interface, mainboard and ac adapter, two analog and digital outputs, and two digital inputs.

Burkert Fluid Control Systems; 949/223-3100; www.burkert-usa.com

MOTION DOES HMI

CP26xx Panel PC series with ARM Cortex A8 processor has a hardware-based floating-point unit, which makes floating-point operations significantly faster for motion control applications in addition to running the HMI software. An on-board 10/100BaseT Ethernet adapter, an EtherCAT adapter with RJ-45 connector and an RS-232 interface with two USB 2.0 ports are also available. The multi-touch panels with projective capacitive touchscreen (PCT) technology have a high touch-point density, and response is assured even while wearing thin work gloves.

Beckhoff Automation; 877/twincat; www.beckhoffautomation.com

PID CONTROLLER

PXU PID controllers come in 1/16-, 1/8- and 1/4-DIN size models, and include optional RS485 communications. They're also programmable via front-panel pushbuttons and/or Crimson configuration software, have on-demand auto-tuning, and have universal inputs supporting thermocouple, RTD, 0 to 10 Vdc and 4-20 mA. They're UL-listed to 61010-1.

Red Lion Controls; 717/767-6961; www.redlion.net/PXU

WELL-HEELED SECURITY

M580 ePAC has Achilles Level 2 Certification for cybersecurity. Firmware integrity is checked at every start-up, and is compiled and stored in memory, preventing its decompilation by a third party. Upgrading to the PAC is possible without additional investment in wiring, software development or training. It's compatible with the xBus communications of the Modicon M340 and Premium PLC. Users can switch between the controller sizes in the Modicon range without changing I/O racks and cabling.

Schneider Electric; 877/342-5173; www.schneider-electric.com/us

PLUS A KEYPAD

iPC-Plus industrial computer includes a 15-in., front-panel keypad model, Intel Dual Core i5 and Quad Core i7 processing, UL/cUL hazardous location testing approval and a 55 °C rating. It offers three backplanes with various combinations of PCI and/or PCI Express (PCIe). All models come with a powder-coated aluminum front bezel and analog resistive touchscreen, 4 GB of DRAM, an 80-GB solid-state drive, a SATA DVD-R/W drive, Windows 7 Pro 32-bit operating system and 100-240 Vac power supply.

Nematron; 800/636-2876; www.nematron.com

GAP FILLER

Programmable and modular PCU Safety Control Unit bridges the gap in technology between traditional safety relays and PLC systems for safety device integration for machinery builders, rebuilders and users. PCU/1 main control unit is modular with 14 expansion modules, has up to

128 inputs, 16 dual-channel safety outputs and 16 status outputs. An available, integrated PCU/1 main unit has PCUEU/1 for adding multiple safety devices integration for switches, mats, edges, bumpers, etc. It's certified up to CAT 4 SIL CL 3 SIL 3 Ple safety level.
Tapeswitch; 800/234-8273; www.tapeswitch.com

HARSH HANDLING

HEC-P5000 harsh environment controller is RoHS-compliant, has an operating range from -40 to 80 °C, sealed, water-tight enclosure, analog and digital I/O, high-speed counting, TCP/IP, communications ports, CAN network communications and Structured Text programming. Program using EZ Ladder Toolkit PC-based software that parallels the IEC-61131 standard.
Divelbiss; 800/245-2327; www.divelbiss.com

CAN BE TAKEN TO EXTREMES

AC500-XC PLC is protected against extreme conditions, eliminating the need for sophisticated protective enclosures. The operating range is -30 °C to 70 °C, with reliable system start-ups as low as -40 °C. Circuit boards are conformally coated to protect against high humidity levels, and it has extended immunity against atmospheres with corrosive gases. Vibration and shock can be tolerated, with accelerations up to 4 g from random vibrations up to 500 Hz, or 2 g from sinusoidal vibration. It also offers extended EMC protection.
ABB; 262/780-3000; www.abb.com/plc

STANDARDS-BASED PROGRAMMING

MPiec machine controllers have a motion engine integrated with IEC61131-3 and PLCopen programming standards, and provide scalability from single to 62-axis applications within company's MotionWorks IEC development platform. Sigma-5 servos are easily accessible through a built-in web server, and they have reusable program code libraries for PackML, camming and a variety of other functions to reduce development time.
Yaskawa; 800/927-5292; www.yaskawa.com

MULTIPLE BATCH CONTROL

N410 panel-mount batch controllers have a full numerical keypad and a modern LCD display, and they provide multiple batch control data simultaneously, including a graphical indication of the batch process and relay status.
Fluidwell; +31(0)41303430786; www.fluidwell.com

CAN'T BE SHOCKED

LPC-630F fanless, small-form computer has an Intel 3rd-generation Core i7 mobile processor, 2-gigabit LAN, two USB 3.0, four USB 2.0, Serial/RS232, e-SATA, Intel HD4000 graphics, two DisplayPort, DVI-I and audio in/out ports. It supports up to 16 GB of DDR3 memory, has optional, built-in 802.11 b/g/n wireless networking, and a 120-GB solid-state drive to protect against vibration and shock.
Stealth; 905/264-9000; www.stealth.com

VERSATILE CONTROLLER

Model BB is a low-cost platform that can act as a programmable automation controller, as a data gateway to existing controllers or as a data logger. Other functions include alarm or event notifications via email/text message. Ethernet, serial, USB and local I/O are options. An embedded web server allows the device to provide an operator interface that can be viewed via wireless/Bluetooth/cell to any web browser, including those on tablets and smart phones. An embedded firewall is included.
SoftPLC; 512/264-8390; www.softplc.com

DUAL RESETS

TCN Series temperature controllers have dual preset indicators, newly developed PID control algorithm and 100-ms high-speed sampling. They have eight types of input sensors, built-in relay output or SSRP output selectable, and 2EA alarm outputs. SSRP output makes phase control and cycle control possible (ac power).
Autonics; 847/680-8160; www.autonics.com

MORE, MORE, MORE

Find more automation and controls product and software roundups at www.ControlDesign.com/roundupsarchive.

TOUCHPANEL PC

GK-7000 touch-panel PC runs on Windows CE 6.0 and has an optional built-in rechargeable battery. It has a 7-in., 800 x 480 TFT color display with a four-wire resistive touch panel. Its Samsung ARM-based S3C2416 32-bit, 500- MHz processor is powered from regulated 9 to 12 V supply, and uses 8 W of power. Built-in interfaces include USB 1.0 x 3, USB 2.0 x 1, RS232, RS485, SD slot, and opitonal extras include 802.11 b/g Wi-Fi, GSM/GPRS, Bluetooth, VESA 75mm rail-mount and 2000 mAH battery.

Lilliput Electronics/Saelig; 888/7saelig; www.saelig.com

TWO OR MORE IN ONE

OmniClient runs real-time control and visualization simultaneously on one computer. It uses an Intel Core i3/i5/i7 processor, and includes Wi-Fi, Bluetooth and RFID. It's shock- and vibration-resistant, thermally stable, has an IP65 front panel, and is EMC compliant.

Kontron America; 858/677-0877; us.kontron.com

RIO MULTIPLIER

RIO-47142 Pocket PLC includes an internal switch with two Ethernet ports for daisy-chaining multiple RIO units. Each RIO unit is self-contained, and provides 32 optically isolated digital inputs and outputs, and 16 analog inputs and outputs. The controller can be programmed using company's standard two-letter language. Software is available for converting relay adder logic into code for input into the RIO controller.

Galil Motion Control; 800/377-6329; www.galilmc.com

REDUNDANT OPTIONS

RMCTools software, supporting the company's RMC motion controllers, includes built-in support for connecting to redundant sensors, support for gathering feedback information from multiple sensors of different types, and the ability to mathematically generate feedback inputs to control loops. User has flexibility in defining the logic by which the feedback is selected, permitting various types of redundancy methods. The controllers can switch between feedback sensors on the fly in position, speed and pressure-control applications.

Delta Computer Systems, 360/254-8688; www.deltamotion.com

A LOT IN ONE

AKD PDMM combines a multi-axis motion controller, complete IEC61131-3 soft PLC, EtherCAT master and AKD servo drive in one compact package to reduce panel space, and simplify wiring and integration, while increasing flexibility, scalability and performance. In addition, the device is fully programmable through KAS Integrated Development Environment, and its solution is scalable from one axis to 128 axes with one controller.

Kollmorgen; 540/633-3545; www.kollmorgen.com

HIDEAWAY PLC

FX3S battery-less PLC for space- and cost-conscious applications requiring up to 30 I/O includes integrated ac power supply, maintenance-free EEPROM memory, and built-in USB port for the programming communication function. This enables high-speed communication at 12 Mbps, built-in positioning control and integrated real-time clock. Programming is via GX Works2 or GX Works2 FX.

Mitsubishi Electric; 847/478-2100; www.meau.com

You Are Here

by Hank Hogan, contributing editor

IF YOU WANT to know where you're going, it helps to know where you are. For machines engaged in motion control, satisfying that truism starts with resolvers and encoders. These devices measure position and velocity, information that's fed into the controller to output commands needed to control machine movement. Selecting the right solution for a particular problem involves answering questions about the environment, type of position information needed, and mounting and connectivity options.

The environment is the first consideration, as can be seen by the basic technology used in a medical setting. Such locations often require any system be immune to and produce as little electromagnetic interference as possible. That, in turn, can dictate what type of encoder to use.

"The absolute optical encoders are typically used in medical applications, such as bariatric beds and scissors lifts, as well as in the vicinity of the CAT scan that rotates around you," says Cory Mahn, senior product engineer with encoder and resolver supplier Dynapar (www.dynapar.com).

Dynapar explains that a resolver is "a special type of rotary transformer that consists of a stationary stator and a rotor that moves with the load. Voltage from the input winding couples to the output winding with a magnitude that varies as a function of angular position."

This construction makes a resolver a simple, inherently absolute, highly reliable position feedback device. There are no onboard electronics, making resolvers the position-information device of choice for harsh conditions, such as temperatures up to 200 °C, elevated radiation levels or a high degree of contamination, as well as settings with high shock and vibration.

A downside of resolvers is that translating their output into useful position information is left up to the machine maker or end user. That can be challenging, which is why encoders are often used.

An encoder provides position information by capturing the passage of an optical or magnetic mark past a point. The mark could be on a shaft that turns in response to movement, so it can be used to track motion. Optical encoders tend to offer higher resolution, with more pulses generated, for instance, per revolution.

"Higher resolution is beneficial in speed control, especially at lower speeds," Mahn says. "If there's a lot of rotation between edges of pulses, you can get velocity ripple between edges, and it's difficult for a drive or motion controller to keep that speed steady."

For an encoder, the first basic choice is between optical and magnetic methods, with the selection often dictated by the environment. If strong magnetic fields are present, or if it's necessary to minimize any electromagnetic interference, then an optical method might be the best choice. On the other hand, in dusty settings, an optical system could quickly fail, while a magnetic encoder continues to function.

Beyond environment, the next consideration is the type of motion to be monitored and what the manner of feedback should be. The motion is classified as either linear or rotary. The second has two basic categories: absolute and incremental. An absolute feedback device gives independent position information, while an incremental one provides current information relative to a previous position. Selecting between these alternatives comes down to what information is required for motion control.

■ A downside of resolvers is that translating their output into useful position information is left up to the machine maker or end user. That can be challenging. ■

"Do you need to know the actual position of the encoder when you power on and power back off again? Or are you just looking for speed information?" asks Mandee Liberty, encoder product specialist at Sick (www.sickusa.com). The company offers many encoder and motor feedback products.

The type of location information needed varies with different applications. It might be important to know how fast a conveyor belt is moving, but not the position of a particular point. On the other hand, a robot using an absolute encoder can pay dividends in shortening start-up times and reducing power consumption. By knowing where it is in a motion cycle, a robot can stop in mid-movement, and avoid having to rehome at start-up and shutdown.

It's also the case that knowing absolute position over time allows calculation of speed. The most basic absolute-position encoders only provide position information. In contrast, the latest generation of these devices, particularly those using some sort of fieldbus, are incorporating velocity calculations, adds Liberty.

With regard to price, absolute encoders are generally more expensive than the incremental variety. That's

because the absolute encoders are a bit more complex than the equivalent incremental device.

The final set of considerations involves mechanical and networking options. With regard to networking, the output can be a standard incremental signal over HTL/TTL, or it can be transmitted over Ethernet, a newer approach that is gaining favor. The choice of interface also sets the refresh rate of the position data.

> It might be important to know how fast a conveyor belt is moving, but not the position of a particular point. On the other hand, a robot using an absolute encoder can pay dividends in shortening start-up times and reducing power consumption.

As for mechanical options, there are a number of choices for shaft and flange size. Other elements of the mechanical package determine how well the encoder operates in settings that are vibration-prone, dirty or wet. "There are varying degrees of robustness within different families," Liberty says. "Some are considered heavy-duty, and some are considered light-duty."

At Dynapar, this distinction shows up in how well encoders are sealed against the elements. A heavy-duty encoder has NEMA- or IP67-certified protection against such environmental assaults as washdown by water jets, according to Dynapar's Mahn.

In general, the higher the IP rating, the greater the attention paid to seals and coatings. That's the only way to bolster ingress protection and, therefore, the IP value. For instance, instead of a simple gasket, the system might use multiple levels of interlocking flanges. These are often partnered with complex seals. The combination can drive up cost and increase size.

In some situations, there's little choice because the motion control being tracked is taking place in a particularly demanding location. Dynapar, for instance, offers products that it classifies as light-, industrial- and mil-duty in terms of their ability to withstand harsh conditions. The last category can be used outdoors, illustrating how robust these systems can be.

Speaking of this, Mahn says, "I know of an application where an SL series is installed on a drawbridge. We're tracking the motor speed and possibly the angular position of the drawbridge." CI

What Are Our Wireless Options?

WE'LL SAVE OURSELVES and our customers some significant money by using wireless sensors in places to connect a battery of machines across varying distances, many nearly 1000-ft distant. First issue: The sampling rates will vary from 10/sec to 1/sec, with some others transmitting on status change only. So it looks like we have options for powering the sensors. At these rates, can we economically use energy-harvesting methods? What's the general state of battery life for these conditions? There even are a few spots where photovoltaics (PV) is an option. Second issue: We heard that the level of encryption (say 128-bit) has a big effect on battery life, which no one seems to want to talk about. Any practical advice for these issues?

—from March '14 CONTROL DESIGN

ANSWERS

Check Your Data Rate Needs

Technology can deliver low-power wireless sensing, but there are challenges such as range, rate, power and encryption to consider.

An excellent way to extend range is with wireless meshing technology. Mesh solutions based on 802.15.4e are far more robust and resilient than 802.15.4, and they'll provide the most flexibility and reliability. A 1,000-ft. range is workable, although environmental factors such as RF interference, frequency choice and the presence of physical objects in the line of sight will affect the range. To get the maximum range, you'll need an external antenna, rather than an on-board chip antenna. Gain and antenna type (directional or omni) will be determined by the local environment.

Ten samples per second is a high rate for a battery-powered sensor node. Do you require that much raw data for the application? You can preserve a lot of battery power if you push some event processing out to the sensor nodes and let them make decisions about how much data really needs to be transmitted. If high data rates are truly required, some wireless technologies will prove to be impractical.

Consider the total amount of data that will pass through the system. The total number of nodes, combined with their sampling rates, will determine the bandwidth that the system design must be able to handle.

Sampling rates heavily influence power budgets. As the sampling rate rises, you're looking at either larger batteries or shorter battery replacement intervals. Note that the industrial process world has gotten good results with WirelessHART. Many products boast multi-year battery life in applications that call for several samples per minute using just one or two D-cell lithium batteries.

Energy harvesting is becoming more viable all the time, but it does call for careful system choices. Photovoltaic power (PV) is still the most practical option, and it works well outdoors. Indoor PV provides much less power. It can work, but only in applications with lower sampling rates and lower range requirements.

To your second issue: encryption adds overhead. How much overhead will depend on data payload packet size. Always factor encryption overhead into the power and bandwidth budget specified by the vendor. And don't take chances with the "security by obscurity" rationale, where security depends on the secrecy of the system's implementation or its components. That's like thinking you can leave your back door unlocked because a burglar can't see it from the street.

MIKE FAHRION, director of product management, B&B Electronics, www.bb-elec.com

[The following response came as a result of posting the question to our own CONTROL DESIGN LinkedIn Group.]

Saving Money Isn't the Big Factor

From my personal experience with wireless instruments and sensors, the majority of these types of instruments have non-rechargeable batteries. Unless you have a huge amount in backup for them, you can't guarantee a continuous measurement of your process. On the other hand, it's the responsibility of a capable technical service group to ensure the minimum power consumption via device configuration.

Finally, saving money must not be a factor when you decide to use wireless instruments. The money that you save in installation and engineering might be spent in medium term by replacing batteries and paying for technical service.

I've seen that the only advantage about wireless instruments is if they can be locally powered by PV solutions or by ensuring continuous power from any power source.

JAVIER ERNESTO OTÁLORA SÁNCHEZ, control design engineer, Genser Power, www.genserpower.com

[These are responses received when we posted the question to LinkedIn's Industrial Automation & Process Controls group.]

Don't Worry About the Encryption Overhead

With the technology on the market today, you have a choice between proprietary wireless products or those conforming to a standard. Both ISA100 Wireless and WirelessHART conform to standards (different ones). Both use AES-128 encryption. Battery life for both depends on the frequency of transmission. ISA100 is capable of transmitting 10/sec, but not WirelessHART. Typically, battery life can be expected to be between one and five years. Either one can be powered by energy-harvesting devices, especially those using the ISA100.18 specification for energy-harvesting power connection. Reducing the length of the encryption key will have no effect on the power consumption, but you can't do it with current products anyway.

DICK CARO, industrial networking consultant, owner, CMC Associates, www.linkedin.com/in/dickcaro

Need Backup

WirelessHART transmitters have demonstrated six-year battery life in the Arctic on actual installations. Update rates are generally one minute or longer on those applications. They should go for nine or 10 years. Naturally, as the update rate increases, the battery life will decrease. At one-second updates, battery life will be from about seven months to 1.5 years, depending on the transmitter type.

JULY'S PROBLEM

WE HAVE CUSTOMERS with varying preferences for the method of terminating field connections outside the panel. We even have our own internal disagreements. We'd like to move toward some simplification and wonder if anybody, whether vendors or independent test centers, etc., has compiled meaningful data about termination failures, meaning some MTBF comparisons that include M8/M12 as well as screw, spring and IDC. It would help to argue a preference based on data rather than mostly subjective or anecdotal viewpoints.

SEND US YOUR COMMENTS, SUGGESTIONS OR SOLUTIONS FOR THIS PROBLEM. We'll include it in the July '14 issue, and post it on ControlDesign.com. Send visuals if you'd like—a sketch is fine. E-mail us at ControlDesign@putman.net. Please include your company, location and title in the response.

HAVE A PROBLEM YOU'D LIKE TO POSE to the readers? Send it along too.

There are energy-harvesting products available today that can be interfaced with WirelessHART transmitters. Two primary energy sources are thermal and vibration. The normal method of interface is to use a purpose-built power module with provision for an external energy source. If the external energy source is providing enough power, it feeds the transmitter. If it drops out for any reason, then the power module picks up the slack and prevents loss of the transmitter from the network. With this supplemental methodology, the power module life on a one-second update application can be extended to four years or more.

KEITH WEEDIN, business development manager, PCE Pacific, www.pcepacific.com

[These are from LinkedIn's Automation Engineers group.]

Just Do Monitoring

Have used wireless sensors for temperature transmission. The sampling rate was every 60 sec. The battery we used on them lasted from five to seven years. I did not see any significance of the encryption having an effect on the battery life. The more you transmit, waking the device up, the more power you would use. I am not confident with the equipment yet to use it for control at this time. For monitoring it is great.

BILL FRIDEGER, HDL Process PC&IS engineer technician, Procter & Gamble, www.pg.com

Test Energy Consumption First

We have deployed hundreds of wireless sensor products. There is a tradeoff on speed or sampling rate, power needed for the device, and radio and battery life. One of our suppliers will do testing on a previously unused device to determine minimum values for current, voltage and power uptime for stability. They then provide battery-life values, which drives your PM program.

CHRIS BRAMLAGE, sales and marketing manager, C&E Sales, www.cesales.com

[And from LinkedIn's Automation.com group.]

All About Frequency

I have dealt with solar-powered seismic sensors. Increasing the time between samples greatly decreased the power requirements, thus allowing the use of smaller and less expensive solar panels. The question is what is the minimum number of samples required per time period to meet the desired functionality.

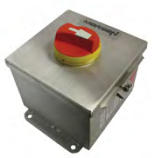
DAN MAZORRA, project engineer, EMA, emainc.com CD

WON'T TOUCH THAT

RFC4800 touchless rotary angle sensors provide absolute rotary position. Analog, digital, redundant and switch are standard output options. It uses a magnetic pickup to provide a touchless measurement range of 0° to 360°. Key specifications include ingress protection from liquids and dust to IP 69K, repeatability of 0.1° and independent linearity of ±0.5%.

Novotechnik; 508/485-2244; www.novotechnik.com

TOUGH SWITCH



EBGS403RS0-H enclosed disconnect switch has 16-gauge 304 stainless steel; a continuous hinged cover with secure latch; wide, welded mounting flanges; DIN rail welded directly to the back of its enclosure; foam-in-place polyurethane gasket; and ground studs welded to door and enclosure. It's commonly used for 30 A applications, but rated to 40 A.

Mersen; 978/462-6662; www.ep-us.mersen.com

GREAT THREADS

WMX general motion controller with up to 64 axes of high-end motion control functions on EtherCAT, has a Windows Class Library that supports up to 256 threads and includes over 200 API functions including EtherCAT network management. Motion functions include jog, PTP, various types of interpolations, listed motion, event-interrupt control and buffered API execution, just to name a few. Override functions are able to change target position, velocity and even profile parameters dynamically during motion. Motion profiles include jerk-free and jerk-limited profiles.

Soft Servo Systems; 781/891-9555; www.softservo.com

DATA PROTECTION

Storm 5100 toughened, water-resistant data displays with integral USB 2.0 interface are encased in a sealed, impact-resistant bezel. The bezel features a hard-coated, UV- and scratch-resistant, polycarbonate window. Available in either 20 character x 4 line, 20 character x 8 line, or 128 x 64 pixel graphic versions in a range of eight different configurations/specifications.

Storm Interface; 480/584 3518; www.storm-interface.com

DC MOTOR CONTROL

Model 0794 enclosed speed control for PMDC gearmotors has forward-brake-reverse switch and dynamic braking, housed in a NEMA 1/IP-20 enclosure. Filtered dc output to the motor allows cooler operation, longer brush life, lower audible noise and wider speed range. It accepts 115-Vac, 50/60-Hz, single-phase input. Power ratings are 7/16 hp at 90 Vds, or 5/8 hp at 130 Vdc.

Bodine Electric; 773/478-3515; www.bodine-electric.com

MAKE SAFE CONTACT

MS-T Series contactors and motor control products range 10 to 32 A. Design is finger-safe and back-of-the-hand safe to prevent contact with a live terminal. Optional streamline terminals improve wiring efficiency, workability, and it's compliant with or approved by IEC, JIS, CE, TUV, CCC, UL and cUL

Mitsubishi Electric Automation; 847/478-2100; www.meau.com

DYNAMIC MOTION

LMS iron-core, linear motor with anti-cogging design for thermal-drift-sensitive precision can be used in machines where a high power density is required with a high dynamic for mid-range moving masses. It has continuous force to 664 N, peak force to 2,760 N with speeds to 15 m/s, has low force ripple and is 600-Vdc-compliant.

Etel; 877/565-951; www.heidenhain.com

SWITCH ON. SWITCH OFF

HP, HE and LE Series pressure switches provide up to 2 million lifecycle ratings. They have an operating range of -40 to 120 °C and accuracy to ±2%. The electromechanical gauge pressure on/off switches are available with single-pole, single-throw, normally open or normally closed circuitry or single-pole, double-throw circuitry.

Honeywell Sensing and Control; 800/537-6945; sensing.honeywell.com

ROLL EFFICIENTLY

Roller pinion system (RPS) for precision linear motion control applications offers linear positioning with zero backlash, more than 99% efficiency and operational life to 60 million pinion revolutions. It features a roller pinion/toothed rack combination. The pinion is comprised of bearing-supported rollers that engage a unique tooth profile. Each tooth profile is measured to eliminate cumulative error.

Nexen Group; 651/484-5900; www.nexengroup.com

STEP RIGHT IN

TMCM-1043 embedded driver stage custom designed for direct mounting on NEMA17 stepper motors is pre-programmed and pre-configured with all operating parameters to support standard 1.1-A motors for rapid design-in and off-the-shelf use without additional programming. With optional programming kit, it becomes a customizable, smart driver stage for a broad range of embedded motion control and mechatronics requirements

Trinamic Motion Control; 49(40)514-8060; www.trinamic.com

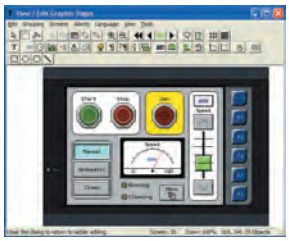
SOFTWARE

HARNESS YOUR CONNECTIONS

Harness proD is a 3D/2D software system for the efficient design and documentation of wire harnesses. Automated steps range from importing mechanical models as 3D environments for wire harness layout and combining them with wiring lists from the Eplan platform to routing the cables and generating the engineering documentation and manufacturing 2D nailboard drawings. It can incorporate mechanically relevant information from various MCAD systems, as well as the ECAD connection information, providing the potential to

be seamlessly integrated into PDM environments.
Eplan; 248/945-9204; www.eplanusa.com

TAG IT



Cscape v. 9.5 control software has tag-based advanced ladder logic to program using tagged variables rather than a fixed register in the target device. It has graphics control and functionality, with background and button gradations on 15-bit or higher color units, smoother gradient transitions on all-in-one controllers that support 24-bit color and bitmap transparency. It supports PID tuning for IEC environments.
Horner Automation Group; 317/916-4274; www.hornerautomation.com

APPLY THE APP

Remote Manager mobile app for Interact Xpress and Factory Display is available for iPhone 4/4S, iPhone 5, iPad2, iPad mini, iOS version 4.3 and higher, and Android OS version 4.2.2. Interact Xpress is a web-published HMI designed for distributed applications and remote support. Factory Display is a compact HMI solution that leverages the availability of the Internet and IP networks.
Parker Electromechanical Automation; 800/358-9068; www.parkermotion.com CD

AD INDEX

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The Most Important Part of Your System

OF ALL THE COMPONENTS in your system, which is the most important? Is it the logic processor? Is it the high-accuracy laser sensor that detects product position? Maybe it's the precision positioning stage that moves the product based on laser sensor input and logic processor commands? Could it even be the operator?

All of these components (with apologies to all machine operators) are important, but there is one that is more so. Oftentimes, this component is not even remotely near the system. It's the documentation.

I simply don't understand the culture in the U. S. about documentation. When did reading the documentation that comes with a system, a machine, an appliance, etc., become not worth the effort or have a negative connotation? Not even all engineers do this absolutely important task. Ideally, I suppose a machine could be so intuitive that no manuals are needed to learn its functions. Steve Jobs came close, but even in iTunes, some features are not immediately clear, and require resorting to the documentation to figure out.

Why is reading the manual for a machine that costs in the six figures considered such a waste of time?

If a company pays hundreds of thousands of dollars for a new machine, wouldn't it be smart to read through the manuals that come with it in order to maximize the return on investment? This seems obvious, yet time and again I've encountered the opposite behavior.

My old company sold machines to a nationally known bakery. The machines performed the same function, but were of several different generations. I was asked to help improve the performance of one of the bakery's newest-generation models. The plant supervisor was unhappy with the machine because it didn't function as well as the older models. I took a quick look at the various adjustment points (some mechanical guide settings, some pneumatic regulator settings). Right away, I could see some of the pneumatic pressures weren't right, but I didn't have the exact factory settings committed to memory. I asked to see the machine manuals, which included all of the parameters as they were set upon leaving my factory. After five minutes of searching high and low through the maintenance shop, they were found. The manuals were in the original, still-sealed, specially-labeled shipping carton.

Why didn't they look at these before calling for help? One might guess that since they had similar machines, they already knew from years of experience how to operate the newer model. The fact they ran into trouble making the machine run properly proves that false.

More recently, I visited a ship that has equipment from my current company. The ship was just out of dry-dock overhaul, and the owner wanted the equipment to get a factory checkout. A technician had been there two days prior to installing all new air valves for the equipment. Since it was in dry dock, the ship was not powered at the time of the valve replacement, so the technician could not check his work. After the ship was powered up, I began tests and discovered two separate problems. I asked to see their equipment documentation. The search for the binder took nearly a half hour. Why is the documentation on a $200,000 system so difficult to find?

Even when the documentation might be available, there's still the problem of why it isn't used. In factories across the country, I repeatedly encounter operators who have never seen the user manuals and maintenance technicians who have never seen the maintenance manual or the parts book.

Part of the problem might stem from equipment that is imported. Much of the machinery used in the United States today is not manufactured here. Every reader probably has encountered a poorly written, poorly translated manual that was not worth the time to read, let alone print. I suppose I could accept that answer for some cases. But that does not give due credit to companies that take pride in the documentation they supply.

My former company had a technical illustrator and technical writer, who created a custom parts book manual and a custom user manual for every piece of machinery that left the factory. These were superbly executed, yet frequently "were lost during shipping." The writer and illustrator began shipping the manuals in that specially labeled carton dedicated to the documentation, and customers still didn't bother to open it.

I wonder why factory managers do not have a documentation set near each machine and another one in the maintenance shop. One might reasonably expect a factory manager to give a copy to operators, with the expectation that their job requires them to read and understand it. CD

TJ MCDERMOTT is project manager at Systems Interface, a system integrator in Bothell, Wash. Learn more about the company at www.systems-interface.com.

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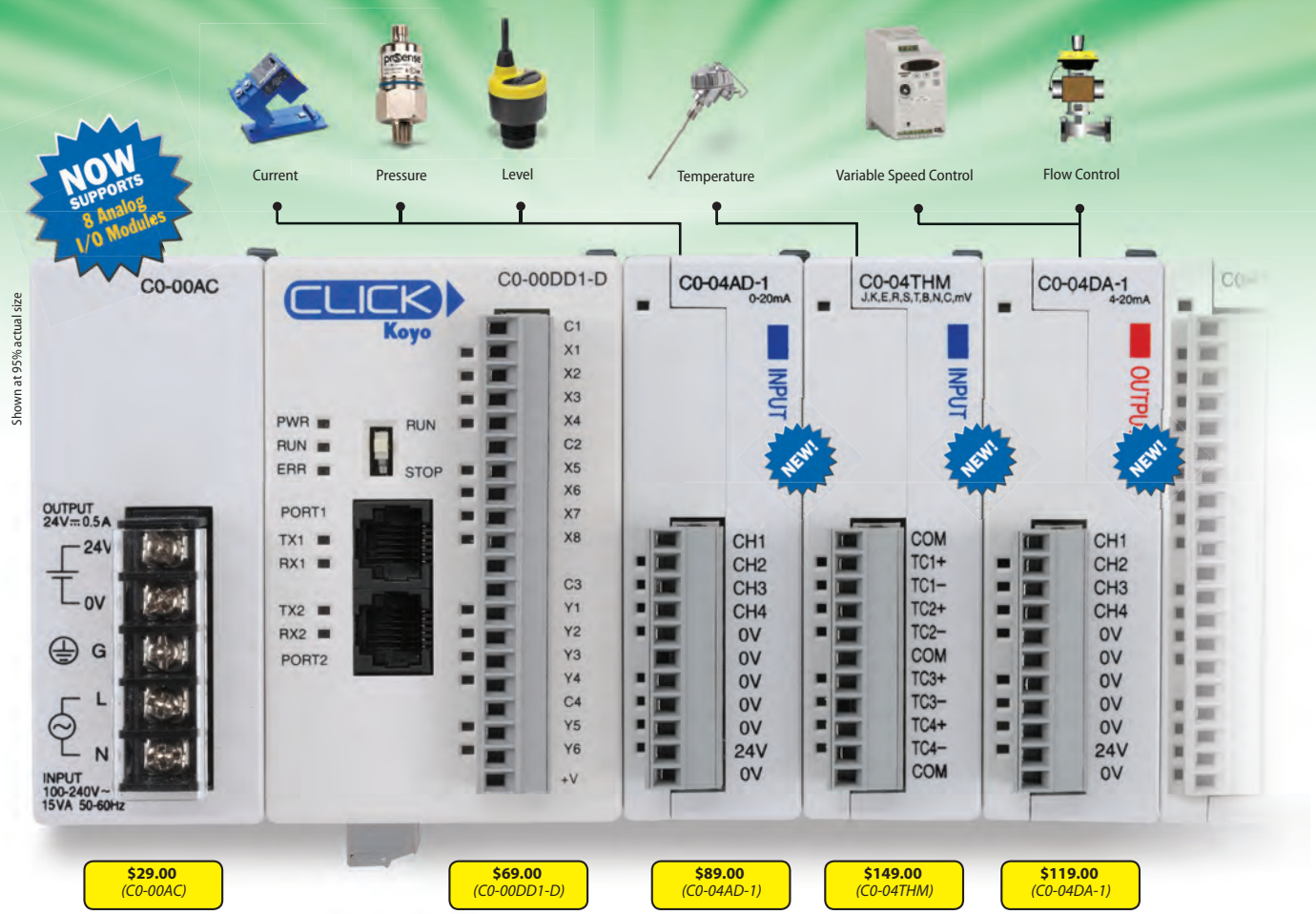

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